RHODESIA

REPORT

of the

COMMISSION OF INQUIRY INTO THE WANKIE COLLIERY DISASTER AND GENERAL SAFETY IN COAL-MINES IN RHODESIA

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Presented *to*

The President

on the 22nd March, 1973

Cmd. R.R. 4-1973. G.P. & S. 62584-6—! 000.

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The President, the Honourable Clifford W. Dupont, I.D., President in and over Rhodesia, Commander-in-Chief of the Armed Forces of Rhodesia and Grand Master of the Legion of Merit.

INTRODUC1 ION

Sir,

By a commission issued on the 4th of September, 1972, we were required ". . . in the light of the accident at Wankie No. 2 Colliery, on the 6th June, 1972, . . to inquire into and report on the following matters—

(a) any question arising out of or connected with the said accident, which, in the opinion of the Commission, has not been adequately covered by any other investigation;

(b) the principal systems of coal-mining practised in Rhodesia, with special reference to safety;

(c) the adequacy of the provisions of the Mines and Minerals Act *[Chapter 203],* and the regulations made thereunder concerning safety in coal-mines;

(d) any amendments to the said Act and, additionally or alternatively, regulations as may be considered advisable and necessary in the interests of safety in coal-mines;

(e) whether the supervision of mines exercised by the Ministry of Mines in terms of the said Act and regulations is adequate, and, if not, in what respects it should be improved in the interests of safety."

The Commission comprised:

Chairman: The Honourable Sir Vincent Quenet, Q.C.;

Members: Mr. Charles Henry Chandler, I.C.D., C.Eng., F.I.M.M., F.R.I.S.;

Dr. Miklos DersO Gyorgy Salmon, Ph.D., Dipl.Ing.(Min.) (Hungary), F.S.A.I.M.M.; and

Mr. Albert Duncan Vos, B.Sc.Eng.(Min. & Met.) Rand, F.S.A.I.M.M.

Before our appointment, an advertisement appeared in the *Government Gazette,* the *Rhodesia Herald,* the *Bulawayo Chronicle,* the *Sunday*

Mail, the *Sunday Times* and the *National Mirror*. The relevant part of the advertisement read:

> "The Commission will be sitting in Salisbury and other centres during the months of August, September and October, 1972. Details of the dates and places will be published in the press in due course.
>
> Persons and bodies wishing to submit representations to the commission are invited to do so by forwarding written memoranda to the Secretary, Commission of Inquiry into Coal-mining in Rhodesia, P.O. Box 8510, Causeway, Salisbury.
>
> Memoranda should be as full as possible. If it is desired that such information be treated as confidential, this must be stated.
>
> The commission will, in due course, be taking oral evidence; but it will be within the discretion of the commission to refuse to hear evidence unless it has been preceded by a memorandum.
>
> Seven copies of memoranda will be required, and should be submitted as soon as possible, but, in any case, not later than the 20th August, 1972. Memoranda should conclude with a summary of the salient points."

Written *memoranda* were received from seven persons—their names are listed in Appendix 'A'.

In terms of *section 5* of the Commissions of Inquiry Act *[Chapter 61]*, the Commission was sworn in on the 4th of September, 1972.

Public sittings commenced at 9.30 *a.m.* on the 6th of September, 1972, and continued until the 8th of September at Salisbury. On the 18th of September, the Commission reassembled at Wankie. On the morning of that day, it inspected the surface installations at No. 2 Colliery and the open-cast workings. At 3.30 *p.m.* evidence was received from certain witnesses. On the morning of the I9th of September, the Commission inspected the underground workings of No. 3 Colliery. Evidence was heard on the afternoon of that day and daily from then until 12 noon on Saturday, the 23rd of September. On the afternoon of that day the Commission left Wankie. On the 9th of October the Commission resumed its hearings at Salisbury, and these continued until Friday, the 13th of October. On that day the Commission ended its public sittings.

Before beginning its deliberations the Commission inquired from the Department of Mining Engineering and the Anglo-American Cor-

potation of South Africa, Limited, whether either wished to lay any further evidence before the Commission. Neither cared to do so. And Mr. May, Q.C., the Corporation's legal representative, indicated he did not wish to address the Commission. No other parties were legally represented.

Twenty-five persons gave evidence before the Commission. Their evidence is contained in fourteen volumes covering 1 282 pages. A list of witnesses appears in Appendix `B'.

The record of evidence, the written *memoranda* and other relevant documents have been lodged with the National Archives for safe keeping.

The Commission is grateful to the Department of Mining Engineering and the Anglo-American Corporation for their ready help at all times. Both willingly gave the Commission such assistance and information as it required.

We wish to acknowledge our grateful thanks to Dr. H. L. Willett, O.B.E.; D.Sc.(Eng.); Ph.D.; B.Sc.(Min.); C.Eng.; F.LMin.E.; M.I.C.E.; F.G.S., and to Mr. Keith H. Saunders, B.Sc.(Min.); M.I.Min.E.; C.Eng., both of whom came from England to give evidence before the Commission. They did so at the Commission's request. The evidence they gave was of the greatest help to us. We should like to record our indebtedness to the National. Coal Board, London, for releasing Dr. Willett and to the National Union of Mineworkers of the United Kingdom for allowing Mr. Saunders to come to this country and give evidence before the Commission.

The Commission is also conscious of its debt to those persons not directly connected with either the Department of Mining Engineering or the Wankie Colliery Company, Limited, who were good enough to give the Commission the benefit of their views and experience.

We should like to record our appreciation of the help given to the Commission while at Wankie by the Magistrate, Mr. R. S. MacKay, and his staff.

The hearings and general business of the Commission went smoothly and efficiently. This was entirely due to the organizing ability and 'enthusiasm of Mr. J. W. Sweeney, Under Secretary for Mines, who acted as the Commission's Secretary. The Commission is deeply grateful to him. It is also grateful to Mrs. J. E. Stumbles and her staff for their unfailing attentiveness to the needs of the Commission. It also wishes

to record its grateful thanks to Mr. G. A. Birnie and his team of shorthand writers charged with the business of recording and transcribing the evidence placed before the Commission.

Finally, it wishes to thank the Commissioner of Police for permitting a member of the Force to attend the Commission's public sittings—a duty which, at all times, was performed efficiently and well.

Chapter 1

Before dealing with the specific terms of reference, there are some general matters which should be mentioned.

I.1. A Brief Geological Description of the Wankie Coal-field-

To the west of the Rhodesian watershed, the country falls away into the depressed region known as the Middle Zambezi Valley. This region is filled mainly with Karoo sediments which extend south-west out of the main valley in the vicinity of Wankie. The coal-field lies in this extension *(see, R. L. A. Watson, The Geology and Coal Resources of the Country around Wankie, Southern Rhodesia, page 2).*

The valuable coal seams occur in a series of shales and sandstones which correspond to the Ecca series of the Karoo System of Southern Africa. These beds are considered to be of Permian Age. Overlying these Permian rocks is a series of sandstones and basalts correlated with the Triassic System of Europe *(see, R. B. Anderson, the Mineral Resources of Southern Rhodesia,* which appears as part of *The Mining Industry of Southern Rhodesia, 1961,* published by the Seventh Commonwealth Mining and Metallurgical Congress, *page 43).*

The Wankie Main Seam, the seam which was mined at No. 2 Colliery, is situated at the base of the Lower Carbonaceous Mudstones of the Ecca Series. While it varies in thickness from nothing to about 12 metres over large distances, it is comparatively consistent over the area of No. 2 Colliery with thickness ranging from 6 to 8 metres. The depth below surface of the workings at No. 2 Colliery varies from about 60 metres to 150 metres *(see, vol. 7 page 93).* As the seam is nearly horizontal, the variation in depth is largely due to changes in surface topography. The Main Seam is highly fractured. Within the main bed there is no real bedding or cleat and although signs of major earth movement are rare, small faulting is common. Due to tectonic activity, that is to say, movement in the earth's crust, the whole seam was broken into innumerable blocks of coal. Subsequent compaction has, generally speaking, erased all sign of fractures, nevertheless they are there as planes of weakness which become significant when exposed by mining. Falls which might result are difficult to anticipate or guard against *(cf., Watson, supra, pages 11 and 12).*

1.2. **The Composition of Wankie Coal—**

The properties of the coal in the Main Seam vary with the distance from the base of the seam. Generally, the 'bottom coal' is of low ash (less than 13 *per cent.)* content, low in phosphorus and has a high swelling index. It is, therefore, a good coking coal. When working from the base towards the upper part of the seam the ash and phosphorous contents increase and the swelling index decreases.

A typical analysis of unwashed coal on a dry basis is:

Ash	13,5 *per cent.*
Volatile matter	26,5 *per cent.*
Fixed carbon .	60,0 *per cent.*
	100,0 per cent.

The volatile content of the seam varies with the distance from the floor. The volatile content of the bottom coal ranges from 27 to 29 *per cent.* and that of the top coal from 20 to 22 *per cent.* These values are calculated on a dry basis *(see, vol. 7, page 6).*

1.3. **A Brief History of Coal-mining at Wankie-**

This history is based on Mr. R. B. Anderson's *The Mineral Resources of Southern Rhodesia.*

In 1893, Albert Giese, a young German prospector, learned from an African of "black stones that burn". His information led him to an area about 70 miles (112 *km)* south-east of the Victoria Falls. Marauding Matabele warriors, however, compelled him to abandon his search for coal. In 1894 he returned and pegged the original location on an outcrop of shales in the Kamandama River. He brought back samples of coal which were found to be of good quality. Giese was not able to comply with the conditions laid down by the British South Africa Company which owned the mineral rights and, for that reason, he could not exploit his discovery.

During 1894 the Mashonaland Agency, Limited, acquired from the British South Africa Company concession rights over a large area in the Wankie district. During 1897 Giese was engaged to peg the Concession which covered 400 square miles (1 036 km^2), and in 1900 exploratory work was carried out on the Concession. In 1901 the Wankie (Rhodesia)

Coal, Railway and Exploration Company Limited, purchased the rights of the Mashonaland Agency, Limited. During August, 1901, shaft sinking commenced and " . . . by January, 1902, the main incline shaft or main drift of what became No. 1 Colliery had reached the coal". During September, 1903, the first train arrived at Wankie and the first consignment of coal went south. However, during 1909, owing to the limited demand for coal, the Company went into liquidation. It was immediately reconstructed as the Wankie Colliery Company, Limited, which from 1909 showed a steady output expansion. The output for 1910 was 194 740 tons (177 000 tonnes). By 1927 when No. 2 Colliery was brought into production, it reached 1 004 349 tons (913 044 tonnes) but as a result of the depression No. 2 Colliery was taken out of production. It remained quiescent until 1937. However, in 1938 production exceeded that of the pre-depression years. In 1945 production was over 2 000 000 tons (1 818 000 tonnes).

As a result of the report of the Wankie Coal Commission published during 1949 the Concession area was reduced, leaving the Company with 350 000 000 tons (318 000 000 tonnes) of extractable and saleable coal.

In 1950 Powell Duffryn, Limited, assumed responsiblity for the Wankie Colliery Company, Limited. The increasing needs of the territories served by the Colliery (that is to say, Northern Rhodesia, the Congo and, of course, Southern Rhodesia, as they then were) made it clear that production, then delivering 3 800 000 tons (3 450 000 tonnes) a ear, would by 1956 have to be increased to at least 5 000000 tons (4 500 000 tonnes). In consequence, towards the end of 1953 No. 3 Colliery was brought into production.

During 1953 the Anglo-American Corporation of South Africa, Limited, took over from Powell Duffryn, Limited. A falling-off in demand led to the closing down in 1958 of No. 1 Colliery. No. 2 and No. 3 Colliery were capable of producing 2 200 000 tons (2 000 000 tonnes) each. At the time of the disaster on the 6th of June, 1972, No. 2 and No. 3 Colliery were in active production.

It is not clear when the open-cast workings first commenced. *The* open-cast mine, however, has been in production for many years and still makes an important contribution to the Company's output.

1.4. **Coal-mining at Wankie from 1948 to 1960—**

We attach a general plan of the property showing the collieries, the open-cast workings and various other features *(see, Appendix `G').*

During November, 1948, Mr. L. A. Price was appointed Assistant Colliery Manager at Wankie. At that time, and for some years before, the bord-and-pillar system of mining was practised at Wankie. Mr. Price described conditions as they existed when he came to the Mine:

> when I came to Wankie I found they were blasting off solid with 60 *per cent.* gelignite, and I was told there was no danger of explosion in Wankie, they had been doing it from 1903 to 1948.
>
> Q. You were not immediately convinced, were you, when you heard this? As to the safety?
>
> A. Not immediately. But after I had been here for some length of time I think I was convinced, since this had been going on for nearly 50 years, in fact, the conditions in Wankie permitted this kind of operation.
>
> Q. Was it an open-light colliery at that stage?
>
> A. Yes, they were using candles, carbide lamps and blasting was done by fuses. It was a completely naked-light mine when I first arrived here."

(see, vol. 8, page 12.)

He believed there was stone-dusting at one stage but had no personal knowledge of it or why it was discontinued. He concentrated on the mechanization of No. 2 Colliery—an exercise which was completed in 1951 and involved the introduction of such machines as mechanical loaders, shuttle cars and conveyor belts not previously used at the Mine. In 1950 when Powell Duffryn, Limited, assumed control of the Company, Mr. T. A. J. Braithwaite was appointed General Manager. At that time No. I and No. 2 Colliery were being worked. "The conditions", said Mr. Braithwaite, "were indescribably bad. It was all hand-working . . using very small mine tubs which we subsequently replaced with tubs of larger size. Drilling was by man-drills or jackhammers occasionally. No protective clothing of any kind, boots or hard hats. The general system of illumination was candles and the officials carried carbide lamps," *(see, vol. 12, page L4),* He was positive stone-dusting was not being practised when he arrived, nor was it used at any time during his twenty years at Wankie *(see, vol. 12, page L6).* He estimated at the time of his arrival about 1 500 000 tons (1 360 000 tonnes) of coal were being produced annually *(see, vol. 12, page L5).* He immediately set about the task of equipping the Colliery so that it would produce 5 000 000 tons (4 500 000 tonnes) of coal annually.

> "The decision was reached to equip No. 1 Colliery to continue to produce at the rate of one million tons (909000 tonnes) per year, to reequip No. 2 Colliery to produce at the rate of two million tons (1 818 000 tonnes) per year, and to sink a totally new colliery, No. 3 Colliery, to produce

also at the rate of two million tons (1 818 000 tonnes) per year. There was the five million tons (4 500 000 tonnes). Speaking of the Collieries only, this was a situation which was achieved by the end of 1957 . . ."

(see, vol. 12, pages L6 and L7.)

1.5. **The First Recorded Ignition at Wankie-**

Prior to the disaster of the 6th of June, 1972, two incidents of major importance took place at Wankie.

At 9.30 *a.m.* on the 29th of December, 1960, three persons were severely burned as a result of an ignition of methane in No. 4 Section, Kamandama Area No. 2 Colliery. **The** ignition occurred when a match was struck to light a fuse igniter. The miner-in-charge described the ignition in these terms-

". the whole face area filled with flame. There was no noise. There was a pale blue and reddish flame that moved out from the face . ."

(see, Schedule 6, page 114, "Report on the Cause and Circumstances Attending the Explosion which occurred at No. 2 Colliery, Wankie Colliery Company Limited, on the 6th of June, 1972", by L. Bills, Inspector of Mines to B. Davey, Chief Government Mining Engineer", hereinafter referred to as "the Report").

Mr. Mooney, the Inspector of Mines then stationed at Wankie conducted the investigation. He formed the opinion the evidence indicated that minor ignitions had occurred previously but had not been reported. He went on to say: "Although this accident is the first recorded accident from this cause it is regarded as a timely warning, as conditions in this respect are likely to worsen in the future when the Kamandama and North shaft workings (No. 2 Colliery) approach the Deka fault plane, and the north development at No. 3 Colliery extends under the Matura hills where the depth will be about 1 500 feet (450 metres). Daily gas testing has been instituted in all parts of the mine and a close study is being maintained of all records submitted. A monthly summary of the findings, and further precautionary measures taken, will be submitted to the Chief Government Mining Engineer." *(see, the Report, page 117.)*

In regard to this event Mr. Braithwaite said: "This came as a great surprise to everybody. It was at that time a naked-light mine, a non-fiery mine, . . . It was from that time that we started to take serious precautions in relation to gas and its detection.". *(see, vol. 12, page L8).*

On the 31st of December, 1960, Mr. Mooney, acting in terms of the Mining Regulations, wrote to the Acting General Manager of the Colliery. *Part 1* of his letter applied specifically to No. 2 Colliery and declared that sections 2, 4 and 7 would be deemed to be fiery areas. *Part 2* set out certain general instructions which applied to all shafts in No. 2 and No. 3 Colliery. A number of general instructions followed. The full text of the letter appears at pages 83 and 84 of *the Report.*

On the 17th of February, 1961, and as a result of the detection of small quantities of fire-damp in No. 3 Colliery, "Section 4 in 67 cross-cut South and Section 1 in 49 cross-cut South" were declared fiery areas *(see, the Report, page 85).* The instructions given in *Part 1* of Mr. Mooney's letter of the 31st of December, 1960, were repeated in a letter dated the 16th of March, 1962, to the Chief Government Mining Engineer, Salisbury. Mr. Mooney said, *inter alia,* "The institution of coal dust suppression measures has been under discussion for sonic time with the Management. It was recently agreed that a directive in terms of *section 46* of the Mining Regulations, 1951, was called for in view of the recent ignition of inflammable gas at No. 2 Colliery". *(see, the Report, page 103).*

On the 3rd of April, 1961, the Inspector of Mines addressed a further letter to the General Manager of the Colliery. It was headed "Coal Dust Suppression Measures: Wankie Collieries." The relevant part reads:

> "**In** view of the recent ignition of inflammable gas at No. 2 Colliery and the detection of inflammable gas at No. 3 Colliery, the following instructions are given in terms of *Section 46* of the Mining Regulations, 1951, in the interest of general safety. This directive replaces the previous instruction, which was given on the 16.3.61. Ref. R161113.
>
> (1) All underground working parts of the Collieries where the conditions are dry shall be kept as clear as practicable of fine coal.
>
> (2) Before work is stopped in any part of the underground workings, all fine coal shall be removed as far as practicable.
>
> (3) At all points where the spillage of coal occurs, the accumulated coal shall be cleared daily and the floor of such places shall be kept damp.
>
> (4) The floor of any portion of a haulage road that is liable to become dry and dusty shall be wetted sufficiently to keep it damp.
>
> (5) Sprays shall be fitted at all underground transfer points to keep the amount of air borne dust to a minimum.
>
> (6) No dust laden air shall be discharged into any airway.

(7) Under no circumstances shall fine coal be used for tamping shot-holes."

(see, the Report, page 91).

On the 19th of February, 1962, reportable quantities of gas were found in District No. 30 North cross-cut from the Main West at No. 3 Colliery. On the 4th of April, 1962, this section was declared to be fiery *(see, the Report, page 87).* On the 8th of August, 1962, the conditions under which welding or cutting operations could be preformed underground were laid down by the Inspector of Mines *(see, the Report, page 90).*

On the 15th of October, 1965, the directives which had declared parts of No. 2 and No. 3 Colliery to be fiery were revoked. The letter explained:

> "In view of the fact that the original districts which were given the designation of 'Fiery Sections' can no longer be clearly defined by boundaries, notice of revocation is hereby given . ."

(see, the Report, page 89).

On the face of it, the reason advanced for the revocation would, in our opinion, have supported the conclusion that the whole of both Collieries should have been declared fiery. On the 18th of December, 1965, a defined experimental section of No. 3 Colliery was declared fiery. Mr. Braithwaite's recollection was that the declaration was made at the request of the Mine itself *(see, vol. 12, pages M4 and* M5).

Mr. Braithwaite was asked whether at this time consideration was given to the desirability of stone-dusting the mine. He replied: "I recall conversations with Mr. Mooney in this connexion and we were in reaching a conclusion . . . influenced first by the steps that we were taking at Wankie and, secondly, by practice in similar mining conditions in South Africa, and the conclusion was reached that coal-dust, particularly in the working areas on our main travelling ways, should be controlled by wetting-down and not by stone-dusting." *(see, vol. 12, page N1).* He was asked whether the decision not to stone-dust was based on a belief that the coal-dust was not explosible. He replied: "Yes, its explosibility was, I think, certainly a matter which has been the subject of some research for some considerable time. Then secondly I think another factor which influenced us at this time was the sheer size of the excavation and thirdly the fact that sections were swept and were watered-down." *(see, vol. 12, pages N1 and N2).* And further on: "I think, to put it correctly, we did not regard it as a serious risk. We

regarded dust underground from the health point of view to be a very much more serious risk." *(see, vol. 12, page N3).* Mr. Price was asked: "It is not clear to me, Mr. Price, why it was believed for so long that the coal-dust was a fairly innocuous thing in the Colliery, because literature for a long time has pointed to the great danger of coal-dust and coal-dust explosions. Are you able to tell me why that attitude was embraced for so long at Wankie?" He replied: "Put in those terms, it is very difficult to say why. We just didn't believe there was any great danger from coal-dust in Wankie." *(see, vol. 8, page 13).* And, further on: "I was aware of the fact stone-dusting was conducted elsewhere, but, as I say, the history of Wankie was that we had not done so. I was also aware that it was not general practice in South Africa either. We rather identified ourselves with South African practice." *(see, vol. 8, page 14).*

As we have indicated the directives declaring part of No. 2 and No. 3 Colliery to be fiery were withdrawn. The Management decided, however, to treat No. 2 Colliery as if it were a fiery *mine (see, vol. 7, page 9 and vol. 8, page 25).*

A Code of Practice was drawn up and submitted to the Chief Government Mining Engineer for his information. The Code dealt with the maintenance of flame-proof and other equipment at the Colliery. In his repy, the Chief Government Mining Engineer said, *inter cilia:* ‘, , we have no comment to make on the subject matter. The Code is a valuable guide to the management of any mine and you are to be congratulated on its preparation." *(see, the letter, dated the 2nd of October, 1966, referred to in the Report at page 18).* Two other Codes were issued, one dealt with the detection of methane, its dangers and so on the other with "Standard Procedures—Mechanised Mining"; they are dated, respectively, the 5th of March, 1971, and the 14th of December, 1964 *(see, the Report, pages 104-111).* Apparently, these Codes were not submitted to the Chief Government Mining Engineer for his information.

In the course of his inquiry, Mr. Bills prepared a schedule showing detections of methane in No. 2 Colliery during the period May, 1967, to May, 1972. During this time reportable quantities of methane were found in No. 2 Colliery. There is no record, however, of any report of these detections having been made to the Department of Mining Engineering *(see vol. 1, pages C12 and C22; vol. 6, pages 4-6 and 101; vol. 12, page M3; vol. 8, pages 25-26 and 92; and vol. 7, page 8).*

Mr. Braithwaite left the Mine at the end of September, 1970, and at the beginning of October of that year, Mr. G. J. Livingstone-Blevins took over as General Manager.

1.6. **The Second Ignition—**

About 3.10 *p.m.* on the 21st of October, 1970, an ignition took place in H.E. 3 Panel, No. 2 Colliery. A subsequent investigation revealed that in the course of blasting operations a blown-out shot in the presence of fire-damp led to the ignition. The miner admitted he had not tested for fire-damp before firing the shots and added that for ten minutes before blasting the auxiliary fan had been switched off *(see, the Report, pages 119-120).*

In the course of his report Mr. Price stated—

> "It is, perhaps, fortunate that H.E.3 is kept well watered down and very clean, otherwise an explosion of much greater magnitude could have occurred."

(see, the Report, page 120).

At the end of the report, five matters aimed at improving blasting procedures and preventing the recurrence of such an incident, were mentioned.

> "(1) Methanometers should be issued to the Coal Preparation Gang Leaders in sections where gas is known to occur. The Gang Leader should be trained in the use of these methanometers, and even if a flicker is noted on the gauge the Miner-in-Charge should be informed. This in no way exonerates the Miner of his responsibilities, but it would be an added precaution.
>
> (2) Miners and Shift Bosses should attend a brief lecture, conducted by the Colliery Manager, on the dangers and hazards of methane when related to coal mining.
>
> (3) Additional watering down crews to be allocated to development sections and, in particular, to H.E.3 where the Long Airdox Drill creates a dust hazard when drilling the upper holes.
>
> (4) A mobile fan with vent pipes to be made available to H.E.3.
>
> (5) That new Standing Instructions be drafted, taking into consideration the circumstances which arise in the variety of mining methods practised at Wankie.
>
> These instructions should be so framed that they are of practical value, and should be issued to all mining personnel."

(see, the Report, page 121).

In the course of his evidence **Mr.** Price stated that effect was given to all five matters *(see, vol. 8, page 22).*

Mr. Livingstone-Blevins said when he heard of the ignition he immediately instructed Mr. Price to inform the Government Mining Engineer, Wankie. Later Mr. Price telephoned him saying the Government Mining Engineer would be content with any investigation the Mine might undertake *(see, vol. 7, page 10).* Obviously, Mr. Livingstone-. Blevins has no personal knowledge whether the ignition was in fact reported. Mr. Price could not remember "positively" that he spoke to the Government Mining Engineer about the matter. But he knew "absolutely positively" that the Government Mining Engineer was informed of the ignition (either by himself or by Mr. Papenfus, the Colliery Manager), and the Government Mining Engineer said he would be content if the Mine conducted the investigation *(see, vol. 8, pages 31 and 32).* Here, again, there is an element of uncertainty because Mr. Price cannot say definitely that he spoke to the Government Mining Engineer about the matter.

Mr. Liedberg, the Government Mining Engineer, Wankie, is emphatic he was not told of the ignition and he produced a number of documents in support of his assertion that he was not at Wankie when the ignition took place or, indeed, at any time when it was likely to have been reported to his office *(see, vol. 14, page B8).* We examined these documents but we are not satisfied they exclude all reasonable possibility of a report *having* been made to Mr. Liedberg's office. Had Mr. Papenfus been alive his evidence might have settled the dispute. In any event, none of the persons who gave evidence on this matter was cross-examined nor was the issue investigated in any detail. That being the situation, we are not able to resolve the conflict. All we are prepared to say is that if the ignition was reported it was a grave omission on the part of the Government Mining Engineer, Wankie, in not recording the fact, informing himself of the circumstances surrounding its occurrence, participating in the investigation and, in due course, advising his superiors. On the other hand, if it was not reported, it was an act of serious neglect on the Mine's part because (as the investigation conducted by Mr. Price found) methane in reportable quantities must have been present. And, of course, the finding that a coal-dust explosion had occurred, was of the greatest significance. In this regard, we draw attention to Mr. Price's statement: ". . . a flash ignited the methane and the coal-dust which had been generated by the blast." *(see, the Report, page 120).*

It is impossible to say what effect a report of the ignition to the Regional Mining Engineer, Bulawayo, would have had on the future course of events at Wankie. The first Mr. Bills learned of the ignition was in March, 1972. The information was given to him by Mr. Livingstone-Blevins in the course of Mr. Bills' visit to the Mine. According to Mr. Bills, Mr. Livingstone-Blevins referred to it as a `suspected ignition' *(see, vol.* 5, *page 15).* Mr. Liedberg who accompanied Mr. Bills on the visit said this was the first he heard of the ignition *(see, vol. 6, page 100).*

1.7. **The Disaster—**

At about 10.25 *a.m.* on the 6th of June, 1972, at No. 2 Colliery, a coal-dust explosion occurred underground. The explosion swept through the greater part, if not the whole, of the underground workings. 427 persons died and seven were seriously injured. Of the 427 persons in the Mine, only two survived. On the surface two persons were killed and five were seriously injured. The officials and supervisors directly responsible for the underground operations lost their lives. Of the 425 persons who died in the Mine, those who might have survived the force of the explosion must immediately have been overcome by the poisonous atmosphere which filled the workings. The explosion wrecked the two surface fan installations. It was not possible to effect immediate repairs and, despite every effort, partial restoration of ventilation to the workings was not completed until 4.00 ***a.m.*** on the 8th of June, that is to say, about 41 hours after the explosion. One of the main installations was then brought back into commission.

Immediately after the explosion rescue operations commenced. Although the rescue facilities available at the Mine were not inconsiderable, the magnitude of the disaster made it necessary to appeal for help. This appeal met with a prompt and generous response from the mining industry in Rhodesia and neighbouring territories and, particularly from the mining industry in the Republic of South Africa. Every endeavour was made to re-enter the workings, and efforts to do so persisted in the face of heavy odds. However, the measure of destruction found in the Mine was such as to make it clear there was only a remote possibility that anyone could, even briefly, have survived the explosion. We are satisfied the decision taken by the General Manager on the 9th of June (some three-and-a-half days after the explosion) to suspend rescue work was necessary in the interests of preventing further loss of life, and was fully justified by reason of the dangerous conditions prevailing in the Mine. After the rescue teams had been withdrawn **all**

Regulations, 1961, made under the Mining I

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to the conveyor loading point are all electrically driven, and are supplied with power through flexible cables which in the rough and tumble of coal-getting in semi-darkness, are prone to damage. The electrical components and switch-gear of these machines encounter heavy usage and have to be designed accordingly. Any fault in assembly, or re-assembly after repair, can lead to the ignition of inflammable gas.

The use of welding apparatus underground for repairing coal-mining machinery is often unavoidable.

Should the moving picks of the cutter chain encounter stone or pyritic bodies in the course of coal-cutting operations, sparks capable of igniting fire-damp might be produced.

Mine fires may start as a result of spontaneous combustion of coal or because of the overheating of machinery working under too heavy a load *(see, Dr. Willett's report, dated the 27th of June, 1972, at pages 16 to 17* as to possible ignition agents).

We think, but it is no more than conjecture, that the explosion originated in Matura Main as the result of a blown-out shot, the flame of which ignited fire-damp.

In this regard we have in mind the fact that methane was being encountered in this area with increasing frequency *(see, vol. 6, page I et seq.);* the fact that the blasting pattern recommended by the Management had led to blown-out shots *(see, vdl. 9, pages 21 and 26);* the fact that on the day of the disaster the miner-in-charge of the section was a man with little coal-mining experience at Wankie *(see, vol. 9, page* 19); the fact that the disaster took place at a time when, in the ordinary way, blasting operations would have been at their peak *(see, vol. 7, page 45);* and, finally, if the course of the return airways is examined it is not difficult to visualize the development of an area of still air along the line of the Matura *faces (see, vol. 1, page D19).*

1.10. Nature and History of Coal-dust Explosions-

Coal-dust is the inevitable concomitant of coal production and its explosibility constitutes the most formidable hazard in coal-mining. The seriousness of this danger was recognized to an increasing extent towards the end of the nineteenth century. It was not until July, 1920, however, that the General Regulations were introduced in British coal-mines prescribing safety measures against coal-dust explosions. At about the same time, similar regulations were formulated in many

other countries. Regulations were first introduced in the Union of South Africa in 1910. These regulations were amended from time to time as more knowledge and experience were gained of the nature of coal-dust explosions and the means of their prevention.

We annex a *resume* of coal-mine explosions in Southern Africa in the form of Appendix 'C'.

The potential hazard of coal-dust explosions is best illustrated by the fact that there were fourteen major disasters (involving in each case more than 100 deaths) in British collieries during the forty-year period before the introduction of the General Regulations. Yet during the fifty-two years following their introduction, only two explosions of the same magnitude occurred.

Since that time several excellent texts (including the *Final Report of the Working Party on Coal-dust Explosions, published in 1967* by the National Coal Board, hereinafter referred to as the *"Final Report, 1967")* have been published. We propose to do no more than make some general observations on the subject.

Certain conditions must exist before a coal-dust explosion can occur. First, the coal-dust must be of a composition, dispersability and fineness which will enable it to explode. Secondly, it must be present in such quantity and be distributed in a manner that it will (if sufficiently disturbed) rise in a cloud. Lastly, some form of disturbance must occur to raise a cloud, and enough heat to ignite it must be introduced by some or other agency.

From the practical point of view the most significant aspect of the composition of coal with respect to its explosibility can be expressed as a simple relationship between its inert and volatile matter content. Let the percentages of inert and volatile matter in the coal be S and V, respectively. Here the volatile matter is expressed on a dry and ash-free basis. The explosibility of coal-dust can be defined in terms of an explosibility index proposed by Mason and Wheeler. The explosibility index, Z. is defined by the expression $Z=S/(100 — S)$. According to experiments by Professor W. Cybulski *(see, the Final Report, 1967, page 16)* coal-dust, arising from coal the volatile matter of which is between 10 and 22 *per cent.* is not explosible if its explosibility index, Z, is greater than the corresponding value $(V — 10)/3$. For coals with volatile content in excess of 22 *per cent.,* the explosibility index must exceed four to ensure that the coal-dust is not explosive.

Coal-mining operations create dust which settles and collects on the floor, roof and sides of mine workings. Inevitably, the dust so formed exceeds the *minimum* concentration required to propagate an explosion, that is to say, about 20 to 50 g/m^3 of air. Almost invariably the disturbance required to raise a dust cloud, and the flame and heat necessary to ignite it, are provided by the explosion of a body of inflammable gas, that is, fire-damp. Once a coal-dust explosion has started it tends to become self-propagating as the shock-wave preceding its advancing flame front brings additional dust into suspension.

It is often not appreciated that the explosion of a very small quantity of fire-damp or methane is sufficient to initiate a coal-dust explosion. As little as 0,5 m^3 of methane can initiate a coal-dust explosion. British experiments have indicated that for each one *per cent.* of fire-damp in the air the percentage of incombustible matter in the dust must be increased by one-sixth. Thus, methane may play a dual *role* in a coal-dust explosion—in its ignition and, also, in its development.

Methane, occluded in the coal at the time of its formation, escapes from the coal surfaces which are exposed as mining operations progress. It is a colourless, odourless and tasteless gas. As it is considerably lighter than air, it rises to the roof of the workings. Its main danger lies in the fact that when diffused in air to form a mixture containing from five to fifteen *per cent.* of methane, the mixture is explosive and most violently so when some nine *per cent.* of gas is present. A mixture within these proportions is easily ignited by a naked flame or spark. Many agencies capable of igniting methane are associated with mining operations. In most coal-producing countries, elaborate precautions are taken to reduce the hazard of accidental ignition.

Although similar in many respects, there are significant differences between methane and coal-dust explosions. Fire-damp explosions are usually localized because their spread is restricted to the region where an explosive gas mixture is present. Coal-dust explosions, however, are frequently widespread; this is so because coal-dust is present throughout the mine. Another dangerous feature of coal-dust explosions is that after an explosion the mine atmosphere contains a considerable amount of carbon monoxide. The presence of this highly poisonous gas often adds to the magnitude and severity of a disaster caused initially by a coal-dust explosion. There can be little doubt this happened at Wankie.

The methods by which the coal-dust explosion hazard can be reduced may be grouped into four categories-

(i) reduction of make, avoiding the accumulation of coal-dust *and* providing for its dispersion into the air;

(ii) avoidance of ignition;

(iii) rendering the coal-dust non-explosive; and, as a last resort;

(iv) confining an explosion in space and effect.

To combat the explosion hazard effectively collieries employ, if practicable, methods in all four categories. Many detailed discussions of these preventive measures are available; perhaps the most comprehensive is in the *Final Report, 1967.*

Good "housekeeping" involves clean mining with effective dust suppression measures, usually based on wetting the coal as it is cut, drilled and loaded. Good housekeeping lightens the task of rendering the dust non-explosive. The most effective method of rendering coal-dust non-explosive is to mix it with incombustible dust, usually stone-dust. The use of this method spread fairly rapidly after experiments by Sir William Garforth in 1908. By the late 1920's its effectiveness was not disputed in most coal producing countries. The effect of stone-dust is to increase the incombustible content and, therefore, to increase the explosibility index, Z, of the dust mixture. To be effective in this *role* it must be thoroughly mixed with the coal-dust and it must remain mixed when raised into the air as a cloud. To ensure that this happens the stone-dust must be of a certain fineness and must not cake excessively. According to British requirements, the stone-dust must pass through a sieve of 240 μ mesh, and not less than 50 *per cent.* but not more than *75 per cent.* by mass must pass through a sieve of 60 *p.* mesh.

For many years it was believed the watering-down of mine roadways was an effective way of preventing coal-dust explosions. Although there appears to be a good deal of evidence to indicate that the presence of water will add to safety (by reducing the ease of dispersion of dust and by providing a suppressive effect on the propagation of flame) watering-down is not entirely satisfactory because its effectiveness is reduced, *inter alia* by evaporation. There remains, then, even in wet or damp roadways, an explosion hazard which must be dealt with. Today stone-dusting is generally preferred *(see, Report of the Working Party on Coal Dust Explosions,* issued by the National Coal Board in 1960).

In some countries an attempt is made to isolate various sections so as to prevent a coal-dust explosion from affecting the whole or a large part of the mine. In addition to general stone-dusting, special measures are taken in Britain to ensure that an explosion is not propagated by coal-dust associated with the coal conveyor system *(see, Report of the Working Party on Coal Dust Explosions—Dust precautions in the vicinity of roadheads on coal conveyor roads,* issued by the National Coal Board in 1961, hereinafter referred to *as "The Report, 1961").* Stone-dust or water barriers are 'used to achieve these ends. Our observations concern only stone-dust barriers. We are, of course, aware of research work being undertaken in regard to the use of water-barriers, but the information before us does not enable us to form a firm view as to their efficacy.

Barriers rely for their operation on the shock-wave which in a typical coal-dust explosion travels ahead of the flame. They are designed so as to collapse when the shockwave strikes them, creating a dense cloud of stone-dust just before the flame of the explosion arrives. If the barrier is of correct design, the dust cloud prevents any further propagation of the explosion. Since it is not known precisely how the inert dust arrests an explosion, the design of stone-dust barriers is based on experimental evidence.

Stone-dust barriers consist of a series of shelves on which inert dust is placed. The quantity of dust, the number and construction of the shelves and their distance from each other and from the roof of the roadway are of great importance for the effective operation of a barrier. The distance of the barrier from the region where the ignition is expected is also of great significance. If the barrier is too close to the point of ignition the flame might pass beyond the collapsed shelves before the inert dust is properly dispersed. On the other hand, if the barrier is too far then much of the dust may reach the floor and the remainder may disperse too widely before the flame arrives. Both faults could make a barrier ineffective.

The British concept of designing and siting stone-dust barriers is well described in *the Report, 1961.* A more recent guide is to be found in the form of a pamphlet entitled *"The Construction, Loading and Siting of Stone Dust Barriers",* published by the National Coal Board in 1972.

Finally, it is important to note that while general stone-dusting is designed to prevent the development of a coal-dust explosion, stone-dust barriers can only arrest an explosion once it is in progress.

Chapter 2

***The* First Terra of Reference--**

". . in the light of the accident at Wankie No. 2 Colliery on the 6th June, 1972, . . . to inquire into and report **On . . .**

(a) *any question arising out of or connected with the said accident, which, in the opinion of the Commission, has not been adequately covered by any other investigation."*

On the 15th of June, 1972, an inquiry commenced into the cause and circumstances of the explosion. The inquiry was made in terms of *section 31* of the Mining Regulations, 1961, as amended by the Mining (Amendment) Regulations, 1967 (No. 8). Mr. L. Bills, the Regional Government Mining Engineer and Inspector of Mines, Bulawayo, conducted the inquiry at Wankie. He interviewed several persons, took statements from some, examined records, instructed that plans be prepared and, generally, did all those things which would enable him to report on the cause and circumstances of the explosion. The inquiry ended on the 30th of June, 1972. We have studied his report. It impressed us with its thoroughness, objectivity and thoughtfulness. In our opinion, it is the only "investigation" which falls within the first term of reference.

2.1. **Failure to Realize the Danger of Coal-dust--**

In the second paragraph of his "Conclusions", Mr. Bills said—

> "Following the failure of the management to realise the danger of coal dust in the mine and the failure to systematically remove all fine coal and dust from the open workings and to apply inert dust so as to render innocuous such dust as remained an explosion of coal dust occurred in No. 2 Colliery, Wankie at approximately 10.25 a.m. on the 6th day of June, 1972."

(see, the Report, page 44).

In a word, *Mr.* Bills concluded the Management failed to realize the danger of coal-dust in the Mine; it failed, also, to remove the danger by applying stone-dust. Because of this a coal-dust explosion took place.

2.1.1. As **to the finding that the Management failed to realize the danger arising from the presence of coal-dust in the Mine—**

Mr. Braithwaite was asked: "Were you in possession of literature . . . which informed you of the danger of coal-dust?" He replied:

> "Oh, yes, certainly. The company arranged that we should take a fairly large cross-section of technical journals and we were, of course, constantly aware of not only explosions but various technical discussions and technical papers in connexion with stone-dust *(sic),"*

(see, vol. 12, page N3).

He was referred to the *Final Report, 1967,* and asked whether the journals he had in mind brought home the dangers of an accumulation of coal-dust as vividly as did this report. He replied: "I would say no, particularly in relation to the circumstances as they applied at Wankie." *(see, vol. 12, page* ***N4).*** This evidence and his evidence in regard to his conversations with Mr. Mooney (referred to in *para. 1.5 supra)* leave no doubt in our minds he realized an accumulation of coal-dust represented a potential danger. It was not, however, until after the disaster that he appreciated the extent of the danger. Mr. Livingstone-Blevins' evidence was rather different. This passage from his evidence illustrates his attitude of mind:

> "Q. What precautions had been taken, Mr. Blevins, in regard to coal-dust in No. 2 Colliery? I am talking of the period before the disaster.
>
> A. Prior to the disaster the precautions against coal dust were really to try and eliminate a health hazard and they consisted of watering down all places where people were required to work and travel, which includes all working faces throughout the mine and all travelling ways leading to those working faces.
>
> Q. The return ways didn't come into that picture at all? A.
>
> No.
>
> Q. Why was your attention limited to the health hazard so far as coal-dust was concerned.
>
> A. For two reasons, one based upon my very long experience of South Africa where the coals in the No. 2 seam in the Witbank district are almost identical in volatile content and various other portions of the analysis to the Wankie seam. I know of no coal mine up till the time I left South Africa in the No. 2 seam that was required to stone-dust. I know of nobody who regarded Southern African coal-dusts generally to be explosive except some in Natal."

(see, vol. 7, pages 5 and 6).

After referring to the fact that No. 2 Colliery had been a naked-light mine, he went on to say: ". . I came to the conclusion that if ever a mine had had an opportunity to blow up it was then. I was thus convinced that there was no explosion hazard here as far as dust was concerned." *(see, vol. 7, page 6).* Further on this appears:

"Q. So the business of the mine went forward on the basis that the coal-dust in the mine did not present a danger?

A. That is correct, yes."

(see, vol. 7, page 7).

Apparently, then, Mr. Livingstone-Blevins did not think the coal-dust at Wankie constituted a hazard by reason of its explosibility.

Mr. Price gave evidence on this issue:

"Q. It is not clear to me, Mr. Price, why it was believed for so long that the coal-dust was a fairly innocuous thing in the colliery, because literature for a long time has pointed to the great danger of coal-dust and coal-dust explosions. Are you able to tell me why that attitude was embraced for so Iong at Wankie?

A. Put in those terms, it is very difficult to say why. We just didn't believe there was any great danger from coal-dust in Wankie."

(see, vol. 8, page 13).

At the inquiry into the second ignition which occurred on the 21st of October, 1970, Mr. Papenfus said: ". . . I investigated the circumstances under which an ignition of methane and coal dust occurred . .". *(see, the Report, page 119).* And, further on, this appears : ". . . a flash ignited the methane and the coal dust which had been generated by the blast. It is, perhaps, fortunate that H.E.3 is kept well watered down and very clean, otherwise an explosion of much greater magnitude could have occurred." *(see, the Report, page 120).* Mr. Price was in charge of the investigation and the quotations are from a report which bears his signature. However he told us he was "positive" it was not a coal dust explosion *(see vol. 8, page 16).*

And further on in his evidence:

"Q. And would it appear from that that it was quite clear that you had in your mind the danger of coal-dust?

A. If it wasn't watered down, yes.

Q. Would you say that this remark cannot really be taken as referring to the danger from fire-damp because watering-down is not going to affect the presence or otherwise of fire-damp, is it?

A. No, but what I said was that it was fortunate that it was well watered-down which prevented the spread of the explosion.

Q. Yes, but carry on and what do you say further: [4]. . . otherwise an explosion of much greater magnitude could have occurred'?

A. If it had not been watered-down.

Q. The `otherwise' is important there. It seems to me to indicate that you had in mind the danger of coal-dust?

A. *Yes*, if the coal-dust had not been watered-down it could have propagated an explosion, this I realize.

Q. All right, we won't labour that point unduly. Was anything done in connection with that aspect of the danger apart from watering-down and keeping clean?

A. No, but progressively we intensified our attempts to keep the place clean and watered-down, all parts of the mine."

(see, vol. 8, pages 82 and 83).

There can be no doubt, then, that Mr. Price realized coal-dust was explosible but, like **Mr.** Braithwaite, he did not appreciate the extent of the danger.

if by his finding that the Management did not realize the danger of coal-dust in the Mine he meant the Management did not appreciate the full extent of the danger it represented, we agree with Mr. Bills' finding. Both Mr. Braithwaite and Mr. Price knew that coal-dust was explosible but, as we have said, they did not appreciate the extent of the hazard or that watering-down, good housekeeping and proper ventilation did not provide adequate safeguards. Mr. Livingstone-Blevins said he was aware that the presence of methane increased the explosibility of coal-dust but he regarded coal-dust at Wankie as constituting a danger to health rather than as an explosion hazard *(see, vol. 7, page 11).*

2.1.2. **As to the finding that the Management failed to remove the danger by applying stone-dust-**

Mr. Bills speaks of the failure to "systematically remove all fine coal and dust from the open workings". While ideally "all fine coal and dust" should be removed, no one who has seen a coal-mine in operation would consider it a practicable proposition to comply with this requirement. Dust is cast up by blasting, by coal cutters, it spills from conveyors and settles on the roof, sides and floor of transport roads. And, of course, dust on the roof and sides is particularly dangerous because of its fineness and dispersability *(see, page 72 of the S.M.R.E. Special*

Report, appearing as Part III of the *Final Report, 1967).* In this regard it should be remembered a covering of coal-dust "no more than the thickness of a layer of very thin paper over the periphery of a mine road of the size adopted at Wankie Colliery" would be enough to propagate a coal-dust explosion *(see, Dr. Willett's report, page* 5). Those who manage coal-mines should, therefore, make it their business to se.,, the mine is kept reasonably free of coal-dust.

Except for a short time, probably during the period 1948 to 1950, the Management did not attempt to remove the danger by applying stone-dust.

No one was able to explain why stone-dusting was discontinued.

2.1.3. **Was the failure to apply stone-dust excusable?—**

The factors which influenced the attitude of Messrs. Braithwaite, Livingstone-Blevins and Price in regard to the need to stone-dust may. we think, be fairly summarized in this way *(see,* Mr. Braithwaite, *vol. 12, pages N1 to N4;* Mr. Livingstone-Blevins, *vol. 7, pages 5 to 7 and pages 11 to12;* Mr. Price, *vol. 8, pages 11 to 14):*

(a) The belief that coal in the Wankie Seam was not unduly sensitive or particularly dangerous. The Seam had been worked continuously since 1903 and, as a naked-light mine, until 1960. Conditions favourable to an explosion had, apparently, existed at Wankie for more than half a century, yet no explosion of any severity had taken place (the ignitions of 1960 and 1970 certainly did not fall into that category).

(b) The view they took of the South African practice at mines in the Witbank area of the Transvaal where stone-dusting was not insisted upon. It was considered the coal at Witbank closely resembled coal in the Wankie Seam. The belief that conditions were similar was based, however, on an insufficient examination of all the evidence. We refer, in this regard, to the fact that the mines in the Witbank area had, as early as 1913, been required either to stone-dust, water-down or use other protective measures approved by the inspector of mines. In 1945 an appeal against an instruction to stone-dust succeeded on the ground that the absence of methane made the application of stone-dust unnecessary and on the further ground that there were insufficient quantities of coal-dust to constitute *a* hazard.

(c) The belief that coal-dust was mainly a danger to health and, also, that watering-down would satisfactorily combat the health and the explosion hazard. This view, apparently, was shared by Mr. Mooney, whose ability and judgment were held in high regard by the Management. *(See, his letter dated the 3rd of April, 1961, referred to in para. 1.5 supra.)* It should be borne in mind that although stone-dusting was introduced into the Mining Regulations of the United Kingdom about 1920, for some time after 1920 there was an option either to stone-dust or to water-down the dust to 30 *per cent.* of moisture. About 1940, however, the option went out and since then it has been a statutory requirement that stone-dusting should be applied *(see, vol. 11, page E2).*

It is generally accepted that the principal means of preventing the propagation of coal-dust explosions is by applying stone-dust. That was not done at Wankie *(see, para. 27 of the Final Report, 1967).*

2.2. **Reasons for failure to apply stone-dust-**

In our opinion the Management was wrong in failing to apply stone-dust.

Bearing in mind the factors which influenced the Management and to which we have just referred, we cannot say with equal confidence it should have realized the probable consequences of a failure to stone-dust. We think Messrs. Braithwaite, Livingstone-Blevins and Price *bona fide* believed the safety measures adopted at the Mine were satisfactory and adequate.

2.3. **Inability to determine the initiating cause of explosion—**

Mr. Bills said: "The initiating cause of the explosion has not been determined and it is unlikely that it ever will be as the colliery has been sealed and it is not the intention of management to recover it," *(see, the Report, page 44).* Our views are set out in *para. 1.9, supra.*

2.4. **Contraventions of Regulations—**

Further on in Mr. Bills' "Conclusions" this appears:

"It may be that the incident which brought about this coal dust explosion was due to one of the breaches of the regulations found to have

been occurring, but whether this caused any injuries or loss of life prior to the explosion of coal dust will probably never **be known.** All of the breaches should have been noticed previously by inspectors and the necessary prosecutions instigated and remedial action taken."

(see, the Report, page 44).

At *pages 42 to 44* of *the Report,* Mr. Bills discussed the various acts which, in his opinion, constituted breaches of **the Mining** Regulations, 1961, and the Explosive Regulations, 1970. Dealing first with the Mining Regulations, 1961, he drew attention to:

(i) the fact that welding and gas cutting were taking place in intake airways up to only 500 feet (150 metres) of the working-face. Yet, in August, 1962, by a special requisition issued in terms of *section 33* of the Regulations, such operations were restricted to fixed places in intake airways at least 1 000 feet (300 metres) from the working-faces;

(ii) the fact that approval had been given for the use underground of Fordson Major diesel engines with exhaust gas scrubbers yet diesel engines without exhaust gas scrubbers were being used in the Mine *(see, the Report, pages 42 and 43).*

(iii) Section 52 (4) of the Regulations which provides that "Where underground workings are approaching each other and their distance apart has decreased to 40 feet (12 metres), work on one face shall cease during blasting operations on the other; and where their distance apart has decreased to 20 feet (6 metres) all work on one face shall cease .. .".

In this regard Mr. Bills said: "The method of work practised at Wankie Collieries necessitates the continued working in faces within 20' (6 metres) but an exemption is necessary and has never been granted." *(see, the Report, page 43).*

(iv) the fact that methane in reportable quantities had been detected ". . . over the last few years yet no such reports were received by any inspectors." *(see, the Report, page 43 and sections 77 and 81 of the Regulations).*

We heard a good deal of evidence on this issue. Mr. Davey, the Chief Government Mining Engineer, said he received no reports that gas in excess of 11 *per cent.* had been detected *(see, vol. 1, page C22).* The relevant part of Mr. Bills' evidence reads:

"Q. Mr. Bills, as far as you have been able to find out, were the findings of methane shown on the schedule you prepared for the period, I think it was, May, 1968, to May, 1972, can you find any record of those findings of methane being reported to the inspectorate?

A. No, except that Mr. 'Nevins did mention this suspected ignition.

Q. No, you have told us about that. I am talking about the readings shown on your schedule?

A. As far as I can ascertain there are no records in any of the Mines Department offices referring to these.

Q. Would it be safe to conclude or would the matter be open to doubt that because you have no written record therefore the reports were not made?

A. Well, they certainly were not made in writing. I couldn't say that they were not made verbally, but they certainly were not made in writing.

Q. Should they have been reported? A.

Yes."

(see, vol. 6, pages 4 and 5).

We annex a copy of the schedule as Appendix `D'.

Mr. Liedberg, the Inspector of Mines, Wankie, from November, 1969, said:

"Q. Now, Mr. Bills prepared a schedule of readings taken by the mine of methane in various parts of the mine over a period, I think it was something like May, 1967, to May, 1972. Were you aware that methane was being found in the mine, and reference was being made to it in underground managers' reports?

A. I didn't know there were reportable quantities. I heard now and then methane was detected, but not knowing very much about it I was quite convinced this was not in dangerous quantities, and it was just connected or associated with coal.

Q. But the minimum requirement under the regulations is If *per cent.*

A. Yes. I understood it was not reportable. In other words, less than *11 per cent.*

Q. Who gave you that understanding of the matter, do you know?

A. I said previously the colliery manager, Mr. Papenfus, and Mr. Schoonraad mentioned it now and then, not very often, that they had methane in the mine. But seeing there was no more talk about it, I didn't think very much about it.

Q. Did you not ask for particulars of how much methane had been found?

A. No, I don't think so."

(see, vol. 6, page 101).

And Mr. Braithwaite, who was General Manager until September, 1970, when shown the schedule had this to say-

> ..If I may comment on this up to August, 1970, which is the period with which I was concerned, I notice that ? out of 16 here are concerned with high extraction coal operations. Now, while it is possible that no formal reports were made to the Mines Department in connection with these, I made it my business to keep the Mines Department very fully aware of what we were doing, in conjunction with experimental high extraction mining work. Then, in relation to a number of these other remaining incidents, they occurred, as was to be expected, in the deeper areas. This was not any great surprise to us. But, in relation to your question as to whether I can comment on whether these should have been reported to the Mines Inspector, and whether in fact they were, I am afraid I really cannot make any comment, except to say that the letter of 31st December, 1960, was later withdrawn."

(see, vol. 12, pages M3 and M4.

The letter referred to was from Mr. Mooney, *(see, para. 1.5. supra).*

Mr. Livingstone-Blevins was asked about the matter:

> "Q. You have seen the schedule which Mr. Bills extracted, I think, Mr. Blevins. *This is* a copy. It starts during May, 1967, and continues until 24th May, 1972, so that it is quite apparent that methane in excess of the one-and-a-half per cent, referred to in the regulation was present?
>
> A. That is right, yes.
>
> Q. Were those reported?
>
> A. Yes.
>
> Q. To whom?
>
> A. By the miners to the underground manager and manager.
>
> Q. I was thinking of a report to the Government Mining Engineer?
>
> A. No.
>
> Q. Why was that?
>
> A. I think a certain amount of confusion was present here. We regarded ourselves as a fiery mine ...
>
> Q. Although you had not been declared such? A.
>
> Although we had not been declared fiery.

Q. You had at one stage been declared fiery, or certain sections had been?

A. Certain sections had been declared fiery by the Rhodesian Mines Department. The requirements under their declarations had lapsed as the area had been worked out and we had moved on. This is a matter of history. Under Rhodesian law it is quite true that in a non-fiery mine you are required to report emissions of gas. I repeat that I think that confusion existed here in that we regarded ourselves as a fiery mine and worked No. 2 Colliery as a fiery mine, and under the regulations which we used as a guideline, those being the South African regulations, we are required to record such emissions of gas and the recordings of these emissions are available for inspection by an inspector of mines. I considered—well, I had only then been here about 18 months, 20 months—that this was in order.

Q. Could we just look at the relevant Rhodesian mining regulation. You notice that regulation 81 does not put a qualification on the kind of mine in which methane in excess of the statutory amount is found?

A. That is right.

Q. In fact, regulation 81 is followed immediately by regulation 82 which is a part of the regulations dealing with fiery mines?

A. Yes."

(see, vol. 7, pages 8 and 9).

There are two passages in Mr. Price's evidence which should be quoted:

"Q. Did the fact it was then decided, in the company of Mr. Mooney, that the two collieries would have to run as fiery collieries, affect in any way your attitude in regard to the reporting of methane found in **the mine?** The reporting of subsequent finds of methane in either colliery?

A. We did not make special reports of finding methane, because we assumed from then onwards that there was methane there, and we were working as if it was a fiery mine.

Q. There was nothing said by Mr. Mooney that you didn't have to bother to inform them of further findings of methane in excess of the quantity stated in the regulations?

A. I don't think anything specific was said, but he was very much aware of the situation.

Q. And because he was aware of the situation, did you feel that there was no need to inform them further?

A. That's right.

Q. Of course the regulation is perfectly specific on the point, is it not? A. Yes.

Q. You must inform the Mines Department when methane in excess of the stated quantity is found?

A. Yes.

Q. I believe that miners were encouraged to report findings of methane?

A. Oh, definitely; very definitely."

(see, vol. 8, pages 25 and 26).

And on *pages 91 and 92* of the same volume:

"Q. I think yesterday Mr. Livingstone-Blevins was asked by one of us about regulation 81 which makes it compulsory that the detection of inflammable gas is reported to the inspectorate and if I recall correctly he said that since the introduction of your own code and the decision that you would treat the mine as fiery you felt that this regulation didn't apply any more. Would you agree this is in fact what happened? There was a certain amount of misunderstanding?

A. There was a certain amount of misunderstanding, yes.

Q. I don't quite understand then if you read now regulation 87?

A. We should have reported it monthly which we did not. We were wrong both ways."

It should be noted that Code 1, signed by Mr. Price and dated, the 5th of March, 1971, has a sub-heading entitled: "Reportable Quantities of Methane." *(see, the Report, page 106).* It required the miner detecting a reportable quantity of inflammable gas to report the fact immediately to a Shift Boss—"he will confirm this in his daily report". The Shift Boss, in turn, was required to report the occurrence immediately to the Mine Captain. And *para. (c)* reads:

"The Mine Captain will decide whether the extent of the occurrence or the difficulty encountered in the dispersal of the concentration warrants a direct report to the Underground Manager, other than the routine weekly report detailing all such occurrences,"

We find it odd, to say the least, that, despite the clear language of *section 81* of the Regulations, the instruction issued by the Mine purported to give the Mine Captain a discretion to decide "whether the extent of the occurrence or the difficulty encountered in the dispersal of the concentration (warranted) a direct report to the Underground Manager, other than the routine weekly report detailing all such occurrences".

It is unfortunate that when reportable quantities of inflammable gas as described in *section* 77 are detected *section 81* does not require that the Inspector of Mines should be notified in writing. Had there been such a provision the question whether reports were, in fact, made

would have been placed beyond any reasonable doubt. And there is, of course, an outside possibility (not amounting to a probability) that in his conversations with the two persons he mentioned, Mr. Liedberg did not appreciate they were telling him of detections of gas of one-and-a-half *per cent.* or more. It was not possible to check this point with the two persons to whom he referred — both perished in the disaster.

There were reportable quantities during February, November and December, 1968, and, also, during January, 1969. The post of Government Mining Engineer, Wankie, remained vacant for a period of eighteen months preceding Mr. Liedberg's arrival in November, 1969. Prior to that time, any reports of the finding of gas would, presumably, have been made to a visiting Inspector of Mines or directly to the Regional Government Mining Engineer, Bulawayo. In either event one would have expected to find a record of such reports having been made. If reports were made both before and after Mr. Liedberg's arrival of any one of the many reportable detections of methane shown in the schedule, it is astonishing no record can be found of any such reports either in the files at Wankie or at Bulawayo, or at the Department's Head Office in Salisbury. And there is, of course, the evidence of Mr. Livingstone-BIevins (in respect of the period October, 1970, onwards) and of Mr. Price that reports were not, in fact, made.

The probabilities arising from the evidence support the conclusion that apart from the October, 1970, ignition (in regard to which there is a conflict of evidence), reports were not made to the Inspector of Mines during the period May, 1967 to May, 1972.

In our opinion, the failure to report in terms of *section 81* constituted a serious neglect of duty on the part of the Management. The lawmaker laid an obligation on the Mine to report and provided that a failure to do so would be punishable *(see, section 175 of the Regulations).* The reason for requiring reports to be made is perspicuous—to ensure that steps are taken to safeguard persons engaged in the mining operation. This was not done. It would be easy in such circumstances to Iay blame at the door of the Government Mining Engineer, Wankie, on the ground that anyone who knows anything about coal-mining realizes that methane constitutes one of its greatest hazards. Why did he not, one asks oneself, inquire whether reportable quantities of methane were being found? On the other band, knowing as he must have done that there was a statutory requirement to report its presence when found in the quantities referred to in *section* 77, he might well

have thought: "Well, this appears to be a well-run mine; if methane is found I have little doubt the Mine will report it; it has not done so. Why should I concern myself about it?"

It is not possible to say what the outcome would have been had the detections been reported. And we do not think it profitable to discuss what might have happened had that been done. All we can say is that reports in terms of *section 81* would probably have resulted in No. 2 Colliery being declared fiery and that greater precautions in regard to safety would have been demanded by the Department of Mining Engineering. We are not able to say with any conviction, however, that had the Department been aware of the true position it would have insisted on the Mine being stone-dusted.

(v) In this paragraph Mr. Bills said:

> *"section 148 (2) (b),* requires that no person in or about a mine shall cause or permit any other person to work in a place which is unsafe. If the management were aware that a coal-dust explosion could occur, they were aware that the whole mine was unsafe. The statement in the report concerning the ignition which occurred in HE3 panel on 21st October, 1970, indicates that they were aware of this danger. The statement was 'It is, perhaps fortunate that HE3 is kept well watered down and very clean, otherwise an explosion of much greater magnitude could have occurred."

(see, the Report, page 43).

This matter has already *been* discussed in *para. 2.1.1 supra.*

As regards the Explosives (Licensing and Use) Regulations, 1970, Mr. Bills dealt first with *section 54 (1) (c)* which prescribes that not more than a two days' supply of explosives (other than detonators) may be deposited in an underground store or box at any one time. And *section 54 (1) 0)* provides that not more than one week's supply of detonators may be kept underground at any one time. From estimates given to him by the Management, he concluded that at the time of the disaster, the explosive distributing' store contained four days' supply of explosives and more than seven days' supply of detonators. These two stores, apparently adjacent, were known collectively as the "magazine" and were situate at the foot of the Kamandama Shaft *(see, vol. 6, pages 22-25 and the Report, page 24).*

The explanation given was that-

> ,`. . . the colliery had been working on a two shift basis for a number of years and had only recently completed the 'run down' to a one shift schedule. This had more or **less halved the daily consumption but the organisa-**

tion had not yet caught up and stocks were probably being maintained at the same level."

(see, the Report, page 24, and, also, vd. 7, page 21).

Section 54 (1) (d) requires that a distributing store should be situate in "an unused chamber or crosscut a safe distance from any main drive, shaft, station or travelling way;". Clearly, the site of the underground magazine did not conform to the statutory requirement. Many inspectors of mines must have noticed it but did nothing (as far as we can see) to correct the position. Here, again, the Regulations were contravened but it was a breach in regard to which certain mitigating factors can be advanced.

We are satisfied the disaster was not caused by an explosion in the magazine.

Any of the matters mentioned by Mr. Bills in *Tiaras.* (i), *(ii) and (iv)* could have caused the ignition. On the other hand, the cause might in fact have been unrelated to any of the breaches of which be spoke. As we indicated earlier many causes unconnected with the alleged breaches could have caused the ignition. These breaches should have been noticed by the Inspectorate and appropriate action should have been taken.

2.5. **Responsibility for not applying stone-dust,**

shared—Further on Mr. Bills said—

"The failure to recognize the danger of the dust must be shared, to some extent, by the Government Inspectors, if they were aware of the incidence of inflammable gas then even more so. This failure must be attributed to the lack of judgment and foresight on the part of all concerned."

There appears to be a conflict between that part of Mr. Bills' **report in which** he says—

"the statement in the report concerning the ignition which occurred in HE3 panel on 21st October, 1970, indicates that they were aware of this danger." *(see, the Report, page 43),* and

the opening words of the passage just quoted—"The failure to recognise **the danger of the** dust must be shared . . .". We take these remarks to refer to a sharing of responsibility by the Management and the Department of Mining Engineering.

In so far as the Management is concerned.—We do not doubt the Management was aware of the danger but considered it was not serious and that watering-down, good housekeeping and proper ventilation were sufficient safeguards. What it failed to do was to apply stone-dust, without which no housekeeping can be described as good, and we have already discussed the factors which gave rise to the belief stone-dusting was not necessary.

In so far as the Department of Mining Engineering is concerned—

As long ago as 1958, Mr. Davey (then stationed at Wankie) tried unsuccessfully to explode coal-dust. "Very crude apparatus", so he said, was used in the experiments he conducted. That circumstance, the "tremendous improvement" in underground conditions and the fact that no gas was detected made him feel "reasonably happy" that coal-dust did not present any particular hazard. And that appears to have been his attitude of mind up to the time of the disaster *(see, vol. 1, pages C15 and C16; and page C22).* We accept Mr. Davey's statement when he says he did not know methane in reportable quantities was being found in the Mine *(see, vol. 1, page C22).* We consider it a most unsatisfactory state of affairs, however, that he should for so long have remained in ignorance of the truth. He had left Wankie in January, 1959, and the first ignition occurred at the end of the next year. He lost contact with Wankie, so he said, during the period February, 1959, to 1965. In 1965 he became Chief Government Mining Engineer *(see, vol. 1, page C16).* From then on he went to Wankie at least twice a year more often if he could and, in addition, "he had all the reports coming in (to him)" *(see, vol. 1, pages CIO and C16).* He visited Wankie at the end of 1971 and from conversations with the Management and "his office" (by which we understood him to mean the Office of the Government Mining Engineer, Wankie) he was "quite content" *(see, vol. 1, page C10).* During that visit he did not go underground. At *page C16,* his evidence reads:

> "Q. Did you keep yourself advised in regard to what precautions were taken against coal-dust at Wankie or not?
>
> A. Yes, yes. Well, as I say, I visited Wankie at least twice a year and then I had all the reports coming in to me.
>
> Q. And what was happening in regard to the coal-dust? A.
>
> All my reports were satisfactory.
>
> Q. But what did they say? Did they say that the dust was being kept wet?

A. Yes. I haven't any reports here, but I can remember some in particular and they were all happy about the position, quite satisfied with the position.

Q. Was it a matter which was specifically mentioned in your reports or was it simply a happiness which was implied from their reports? Did they specifically deal with it and say: 'We are satisfied with the measures which are being taken at Wankie to see that coal-dust is kept under control?'

A. The last report prior to the disaster included words to the effect: `It is obvious the management are keeping a good house and are very accident conscious.' "

(see, vol. I, pages C16 and C17).

The letter of the 3rd of April, 1961 *(see, the Report, page 91)* referred to the detection of inflammable gas in No. 2 and No. 3 Colliery. Parts of No. 2 and No. 3 Colliery had been declared fiery *(see the letter of the 31st of December, 1960, and the letter of the 17th of February, 1961, at pages 83 and 85 of the Report).* The Government Ventilation Officer's report of the 22nd of July, 1971, stated, *inter alia:* "At the time of the inspection methane gas was detected blowing from a fissure in one heading." The report ends with this observation:

"The degree of mechanisation coupled with dust and gas control demands a high standard of ventilation."

The report was received by the Department's Head Office in Salisbury *(see, vol. 1, page D20).* The Code of Practice (referred to in *para. 1.5 supra)* which received the Department's blessing on the 22nd of October, 1966, concerned the maintenance of flame-proof and other equipment at Wankie Colliery.

Three matters appear to have contributed to the fact that the Chief Government Mining Engineer was not aware that methane was being detected at Wankie:

(i) the failure of the Management to report its detection in terms of *section 81* of the Regulations;

(ii) a person had been placed in charge at Wankie who had no previous experience of coal-mines; and

(iii) he (that is to say the Chief Government Mining Engineer) failed to inform himself whether methane in reportable quantities was being detected at the mine.

We are not prepared to conclude all members of the Department shared his state of ignorance *(see, for example, the Ventilation Officer's Report, dated the 22nd of July, 1971).*

2.5.1.

The incumbent at Wankie at the time of the disaster gave us the impression he was prepared to accept opinions and assurances given to him by senior mine employees. Unfortunately, his lack of experience in coal-mining disabled him from applying critical standards and of forming an independent judgment of conditions at the Mine. As we have already said, it seems doubtful whether the Department (even if it had been aware of the presence of methane) would have called upon the Mine to apply stone-dust. It is interesting to note that in a helpful *memorandum* submitted to the Commission by Mr. R. Mooney (and received by the Commission on the 16th of July, 1972) he recommends the placing of stone-dust barriers at designated points, yet he makes no recommendation in *regard* to general stone-dusting of the Mine (see, however, his second *memorandum).* It seems to us that both the Department and the Management realized coal-dust could be dangerous, but neither considered it presented any particular danger or that it might, if not properly suppressed, result in a disaster of the kind which did take place.

Mr. Bills said:

> "It is not intended to absolve the company of all blame but one must remember that some of the men who died shared in the decisions regarding safety in the mine. Some of those in higher management and in technical positions, who also shared in such decisions, regularly went underground. These were not men prone to making frivolous decisions when lives were at stake, but were conscientious men directly involved in the efficacy of these decisions."

(see, the Report, page 45).

We think these remarks wholly justified. He ended his report with certain recommendations. In so far as they affect safety, we do not at this stage, intend to examine them. We will, however, take note of them when we make our recommendations.

In regard to the first term of reference we summarize our views in this way:

1. We are satisfied methane was ignited by some unknown agency and this, in turn, gave rise to a coal-dust explosion. *(see paras. 19 and 23 supra).* The principal and generally accepted means of preventing a coal-dust explosion is by applying stone-dust *(para. 2.1.3).* Except for an unspecified period during the middle of the century the Mine did not consider it necessary to apply stone-dust. Its failure to do so arose from a *bona fide* but mistaken belief that the safety measures then in use were

adequate *(para. 2.1.1).* The factors which brought about this condition of mind were, first, the belief that coal in the Wankie Seam was not unduly sensitive or particularly dangerous; secondly, *the* view it took of the South African practice in some Transvaal mines where stone-dusting was not insisted upon; and, thirdly, the belief that any hazards connected with coal-dust could be dealt with satisfactorily by watering-down, good housekeeping and proper ventilation. The full extent of the danger was realized, for the first time, only after the disaster *(para. 2.1.3).*

2. In our opinion, contraventions of the Mining Regulations, 1961, and of the Explosives (Licensing and Use) Regulations, 1970, occurred before the disaster. They should have been noticed by the Department of Mining Engineering and appropriate action should have been taken. Any of them might have caused the explosion. However, as the field of possible causes is considerable, none might in fact have contributed to the disaster *(para. 2.4).*

3. We are unable to make a finding whether the ignition of the 21st of October, 1970, was reported by the Mine to the Department of Mining Engineering. Subject to this, we are satisfied that detections of methane of 11 *per cent.* or over during the period, May, 1967 to May, 1972, were not reported to the Department in terms of *section 81* of the Regulations or at all. The failure to do so constituted a serious breach of duty on the part of the Mine *(para. 2.4).*

4. The Chief Government Mining Engineer and certain members of **his Department were not aware that reportable** quantities of methane were being detected at No. 2 Colliery. For this state of ignorance, they were partly to blame. It seems unlikely that had they known of the detection of methane, they would have required the Mine to apply stone-dust *(para. 2.5).*

Chapter 5

The Second Term of Reference-

". . . in the light of the accident at Wankie No. 2 Colliery on the 6th June, 1972 . .. to inquire into and report on . . . (b) *the principal systems of coal-mining practised in Rhodesia, with special reference to safety."*

Introduction

3.1. Coal is a mineral and is classified as a sedimentary rock. It is of organic origin and is derived from vegetable matter fossilized or partly fossilized by geological agencies in past ages. Several fossil fuels are included under the word Coal—brown coal, lignite, bituminous coal and anthracite—varieties which represent degrees in the alteration of vegetable matter into mineral form. The degree of alteration determines the "rank" of the coal in which term are summed up its physical and chemical properties. In general, the higher the rank the lower the volatile content and the higher the carbon content and the calorific value of the coal.

No other single mineral has played as important a *role* in industrial development. Once its properties became apparent in meeting needs of heat and energy, coal-mining was actively pursued in those countries which were fortunate enough to have coal seams. Mining methods evolved as the outcome of many years of trial and error.

Coal-mining is rightly regarded as one of the more ancient arts and although its methods have now been largely reshaped by scientific discoveries and technological advances, coal-mining has by no means become an exact science. A *degree* of insight and skill (to constitute an art in those who practise coal-mining) is still required if untoward consequences are to be avoided.

This chapter does not purport to deal exhaustively with all known systems of coal-mining or the hazards attached to them. Coal-mining is subject to the general dangers which accompany the mining of any mineral. It carries, however, a significantly higher risk that inflammable gas will be encountered in the workings. In addition, there are the perils peculiar to coal-mines arising from the presence of coal-dust and the particular method of working which has been chosen.

3.2. **Systems of Coal-mining-**

Usage and practice established three main systems of mining coal — Bord-and-Pillar, Longwall and Open-cast. As Rhodesian seams are horizontal, this account does not necessarily relate to inclined seams.

3.2.1. Pillar Systems—

Pillar Systems (variously known as bord-and-pillar, room-and-pillar, pillar-and-stall) are those in which coal is won by driving a series of parallel roads (bords, rooms, stalls) into the coal-seam off the main access roadways. The roads are interconnected at regular intervals by others, usually driven at right angles, to form pillars to support the roof. This primary operation of advancing into the seam may or may not be followed by a secondary operation in which **all** or some of the coal in the pillars, or coal left in the roof or floor in the primary working, is mined on the retreat.

The size of the pillars and the width of the roads are dictated, respectively, by the physical condition of the seam beneath the surface and by the nature of the stratum forming the roof. In pillar mining, safety requires that the greater the depth of the seam and the greater the working height the larger must be the pillars and the narrower the roads. **If** secondary extraction is inhibited by roof conditions, or for some other reason, the amount of coal left in a deep-lying seam might be unjustifiably high.

Reliable methods are available for determining pillar sizes to meet the necessary safety requirements. Pillar mining can be carried out successfully in seams varying widely in height where other methods might be unsuitable. If conditions do not favour open-cast or Iongwall methods, it **is** the only system to be adopted.

3.2.2. **Longwall Systems-**

Longwall Systems are those where the coal is mined from a continuous long face and not from the faces of headings driven to leave intervening pillars. In designing a longwall operation provision may be made for the face to advance away from the main haulage roads towards a boundary; or, if access roadways have been established, to retreat from a boundary towards these roads. In either case the roof is usually allowed to cave in as excavation proceeds and, in the case of an advancing longwall face, the access, haulage and ventilation roadways have to be kept open by providing packing or other support.

Where the seam lies at depth longwalling offers a higher degree of recovery than is possible in pillar mining. A longwall system, however, is not well suited to shallow depths where the systematic caving-in of the roof is difficult to control and stowing of the mined out area is likely to be unduly expensive. It is, also, not suited to a mining height of much more than 2,5 metres because in excess of that height safe support at the face becomes either impracticable or too costly.

3.2.3. **Open-cast Systems-**

Open-cast Systems are those in which the soil and rock overlying a coal-bed are removed to expose the coal and render it accessible to mining. The operation is also known as open-cut or strip mining and is akin to quarrying. The overburden of soil and rock is removed and is invariably dumped back into the excavation as mining proceeds. If the work is properly planned and carried out there will, in the final result, be little disfiguration of the landscape and the surface will be restored to its former usefulness.

Where the overburden is too great for stripping to be continued economically and before resorting to underground methods, an extension of recovery from the open-cast pit may be made by auger mining. In auger mining parallel holes about a metre in diameter and some 70 metres deep, are drilled at right angles into the coal face. As each hole is drilled the coal is recovered in the form of cuttings which are drawn out by the spiral flutes of the rotating auger. The holes are spaced to leave an intervening pillar of 300 to 450 *mm* for support.

Open-cast mining is free of the danger of methane and coal-dust explosions. However, it has its own peculiar dangers. The operation must be properly planned and supervised, and should be carried out by trained and competent personnel.

Economic limitations are imposed on open-cast methods primarily by the depth of the cover in relation to the height of the seam. The relevant costs are largely governed by considerations of the depth and nature of the overburden, the cost of transporting the coal to the market, the size of the market and the quality of the seam itself. The quantity and quality of coal demanded by a thermal power station, for instance, and the location of such a station in relation to an open-cast mine, have an important bearing on mining and transport costs. These factors determine the capacity and type of mining machines and conveying equipment necessary for the operation. The larger the machines and the shorter the transport distance the lower the unit

delivery cost and, therefore, the greater the depth of overburden which can economically be stripped. On the other hand, the larger the machines the greater the capital costs. The economics of any particular open-cast operation demand a specialized study in achieving the correct balance. It is not our province to go into these aspects in any detail. We wish to emphasize, however, that wherever open-cast mining is economically feasible it is the method to be preferred—the dangers associated with it are of a lesser order and a greater degree of recovery is possible.

3.2.4. In relating these observations to coal-mining in Rhodesia, we have concerned ourselves only with the major field in the Wankie area as it is understood that only in this area will mining be carried out in the foreseeable future. In the Wankie area the position is, broadly, that a single seam of highly fractured coal lying horizontally and with an average height of ten metres occurs at shallow depths ranging from less than a metre to some 150 metres depending on the configuration of the surface. The uppermost third of the seam is inferior, the quality of the coal increasing towards its base.

In essence, the most suitable method of mining is that which yields *maximum* recovery at *minimum* cost in the best marketable conditions and with least danger to the miner.

In the geological conditions of the Wankie field, considerations of safety prohibit any attempts—at least in the light of current technology—at longwall working. This method would invite uncontrollable roof movement and underground fires. Even were the geological conditions favourable, practical considerations would limit longwalling to the bottom third of the seam and this in turn would result in an unreasonably low recovery.

In regard to the Wankie field our conclusion is that the interests of safety and coal conservation will best be served by mining the seam by open-cast methods to the limit of the extent imposed by the lowest acceptable economic return. In the remaining extent of the field the coal should be won by bord-and-pillar methods.

3.2.5. In the result, we are satisfied the Company was right in adopting the bord-and-pillar and open-cast systems of mining.

3.3. **Hazards in Bord-and-Pillar Mining in Rhodesia and their Allevia-tion-**

3.3.1. **Planning and Layout-**

3.3.1.1. **Shafts and main roadways—**

Certain basic principles apply to the design of a coal-mine. First the area it is proposed to mine must be defined. Then shaft and underground roadway systems to serve the defined area must be planned. The shaft system is critical to the safe and efficient operation of the mine throughout its working life. It has to provide for the passage of men, materials, machinery and ventilating air into and out of the workings and for the transport of coal to the surface.

At least two shafts are required to serve these purposes. Ideally, the shafts should be situated at or near the centre of the mining area. It is clearly an advantage if the main roadways leading off the shafts to the boundaries of the mine are as short as practicable; that is desirable in the interests of upkeep, access to the workings, ventilation and flexibility of operation.

In the Wankie field an example of sound layout on these principles was observed at No. 3 Colliery. The layout of No. 2 Colliery, the disaster pit, is in striking contrast *(see, Plan No. L.B.W.5. Appendix 11').* The positioning of the shafts, the long lines of communication between the shafts and the sections being worked and the haphazard methods in developing and ventilating the southern and western areas give no indication of careful planning. These deficiencies might have contributed to the disaster and affected its magnitude, and in our opinion call for criticism of those responsible for the layout of the Mine. In fairness it must be said, however, that in certain parts, mining was carried out methodically in a panel system and in an entirely satisfactory manner.

For these reasons it is felt the main roadways of a mine in the Wankie field should not extend for distances greater than, say, 3 000 metres from the coal outlet shaft. The extent of a mine and the location of the shaft should be planned accordingly. The coal occurs at a moderate depth and the capital costs of sinking a shaft to the seam horizon are not unreasonably high in relation to the value of the seam. There is no justification for taking the risk of over-extending the roadway system to save the costs of sinking a new coal outlet shaft and providing for the conveyance of the coal to the treatment plant. At the time of the disaster the workings in the western area of No. 2 Colliery were already some 3 800 metres from the coal outlet

shaft, and it was intended to advance the workings even further to the west. Some time prior to the accident increasing quantities of inflammable gas were encountered and it was becoming more difficult to keep the workings clear of gas. It is not easy to decide whether these warnings should have been seen by the Management as being serious enough to require a drastic revision of the ventilation arrangements of the Mine as a whole. The Mine still had an estimated life of eight years and the sinking of a new shaft to alleviate the position had, apparently, not received any serious consideration.

An important aspect in the design of a mine is that every person employed underground should have access to not less than two separate outlets to the surface. The outlets should be provided with proper ways and means, constantly available for use, enabling persons to travel to and from the surface without undue exertion. Further, a separate means of egress from the working places to each of the two shafts should be within easy reach at all times.

The facilities provided at No. 2 Colliery were certainly not above criticism. Fortunately, deficiencies in the means of egress arising from the fact that neither of the Bisa shafts was equipped to serve as an escape route did not contribute to the loss of life.

Suitable provisions regarding means of egress should be embodied in the mining regulations now in the process of revision. The layout of any new mine or, for that matter, of any existing mine, should be required to conform to these provisions *(cf. sections 6.1.1, 6.1.2 and 6.2.1. to 6.2.5 of the South African Regulations, Chapter 6).*

3.3.1.2. **Layout of working sections in bord-and-pillar mining—**

In the general interests of safety it is essential that a mine should be laid out into working sections in an orderly manner. This is best achieved by dividing the area in which mining will take place into panels, each panel being enclosed within a barrier pillar of suitable dimensions which totally isolates it from adjacent panels.

In gaining access to the coal within a panel from the main roadways it is important that the number of entries driven to pierce the barrier pillar be restricted to the *minimum* number required to mine and ventilate the panel properly.

The dimensions of a panel and its shape might to some extent be dictated by the presence of faults in the strata or by igneous intrusions. Generally, however, in the geological conditions obtaining in Southern

Africa, panels of rectangular shape can conveniently be laid out with their entries driven at right angles to the main roadways.

In designing the width of the barrier pillar and the dimensions of a panel the important considerations to be taken into account are the depth and height of the seam, the degree of recovery which may be expected from the panel and whether mining is to be by mechanized or hand-got methods.

It is not customary for any attempt to be made to mine the barrier pillars when a panel or series of panels has been exhausted. Skilful planning, therefore, is necessary to avoid unreasonable loss of coal in the form of over large pillars and, at the same time, to adequately meet safety requirements.

Panel mining confines production to specified areas; this makes for better supervision and control of the labour force with benefit to safety.

Other advantages of laying out a mine on a panel system are mentioned in the sections dealing with strata control and ventilation *(see, paras. 33.2 and 3.3.4, infra).*

In much of the area comprising No. 2 Colliery the workings were systematically laid out in panels. In the southern portion of the Mine, however, a geological disturbance extending roughly from east to west, led to a departure from an orderly layout. Whilst not underestimating the difficulties which must have faced the Management in exploiting the coal in that portion of the Mine, the way in which the working sections were laid out does not indicate an analytical attitude to the problem but suggests a rule of thumb approach based on expediency.

3.3.2. **Strata Control in primary and secondary workings—**

Rock falls are one of the most frequent causes of mine accidents. Most of these accidents can be prevented if the miners and the supervisory officers are responsible, experienced men. The borcl-and-pillar system of mining, however, has a strata control hazard which is peculiar to it and requires special mention.

In the bord-and-pillar method, as practised at Wankie, the pillars are left behind to provide permanent support for the partially undermined overburden. To fulfil this function the pillars must be of sufficient strength to carry the weight of the rock above them. If they are not the pillars will, at some stage, collapse, possibly causing loss of life or property or initiating even, a major disaster. The most tragic

example of the latter is the disaster at Coalbrook North Colliery in the Orange Free State of the Republic of South Africa on the 21st of January, 1960. The disaster involved the collapse of over 2,5 square kilometres of pillared area and resulted in the loss of 437 lives.

A further hazard associated with the collapse of pillars should be mentioned. Sometimes when pillars collapse the failure occurs suddenly, resulting in a so-called `air-blast'. Such a blast can and often does raise a dust cloud which, if ignited, can lead to a coal-dust explosion. The violence resulting from a pillar collapse might constitute the dust raising agency referred to in *para. 1.10, supra.* Dr. Willett supported this supposition and recommended that pillars should be designed to eliminate the danger of collapse in the future or, if there were areas not stone-dusted and supported by pillars of doubtful competence, they should be isolated by air stoppings which would be able to withstand the pressure of an air-blast *(see, vol. 12, pages D6 to D8).*

Clearly, it is essential to the safety of bard-and-pillar workings that the pillars should be so designed that their falure is highly improbable either during coal extraction or after extraction in that area has ceased. The safety of the whole colliery is increased if it is sub-divided into panels separated from each other by substantial and continuous barrier pillars.

The strength of pillars increases with their width and the load acting on them increases with the amount of coal extracted. Safety considerations, then, would prompt the use of large pillars and the extraction of a low percentage of the available coal. However, the economics of mining demand that as little coal as possible be left behind in the form of pillars. The correct compromise between these two conflicting considerations must be found. Thanks largely to the research effort inspired by the Coalbrook disaster, such methods of design are now available and can be applied at Wankie. The truth of the latter conclusion is supported by the evidence of Mr. Livingstone-Blevins, Mr. Price and Mr. Coetzee, which indicated that the South African method of design is valid in the Wankie Coal-field *(see, vol. 7, page 126; vol. 8, pages 74, 75 and 101; and vol. 4, page 51).*

When a thick seam of coal is mined, as is the case at Wankie, extraction takes place in two phases. During primary mining the seam is worked to a height of about three metres and in the secondary phase the ultimate height of working is reached. The secondary operation can take the form of either lowering the floor level, 'bottom coaling', or placing the roof horizon at a higher elevation, 'top coaling'.

It is essential that the ultimate working should be decided upon at the stage of layout planning so that in the construction of pillars, adequate safety factors will operate at both stages of mining. If the mine is sub-divided into panels by adequate barrier pillars and the secondary operation is carried out on the retreat, it seems reasonable to accept an ultimate safety factor of only 1,4, or even 1,3. However, it is essential to ensure that when such a low safety factor is used the safety factor of the primary workings should not be less than 1,8. This is to guard against the possibility of a 'pillar run' which might be initiated in the top or bottom coaled section of the panel.

Considerable care should be exercised at Wankie when pillars are designed and secondary mining is carried out. This warning is given because of the highly fractured nature of the Wankie Main Seam *(see, para. 1.I, supra).* This feature could easily lead to pillar sinning, which can be extremely dangerous because of the great height of the workings.

Frequent reference has been made to the pillar design method used in South Africa. A comprehensive descriptor of this method will be found in 'A Method of Designing Bord and Pillar Workings' by Dr. M. D. G. Salamon, published in the September, 1967, issue of the Journal of the South African Institute of Mining and Metallurgy.

3.3.3. **Coal handling operations—**

Two methods, hand-got and mechanized, are available. Both have been practised at different times in the Wankie field.

There is a degree of mechanization in all coal-mining operations. In hand-got workings the coal face is cut and drilled by machines. After the face is blasted the broken coal is shovelled by hand into tubs which run on rails. The tubs are pushed by hand to the haulage road where they are fastened to the outgoing rope (in South African practice) of an endless rope haulage installation and drawn out of the mine. Simultaneously the ingoing rope of the installation brings a supply of empty tubs to the in-bye end of the haulage road.

In the accepted meaning of the term "mechanized mining", the coal receives no manual handling. The winning of coal at the face may be carried out by machines, known as continuous miners, of various designs and types. Alternatively, the coal may be broken by the use of explosives. In either event all excavating, cutting, drilling, loading and transport operations are carried out by machines. The powerful machines used for these purposes are capable of high production rates

and because of their size often occupy much of the working and travelling space in the bonds where they operate. They are, generally, powered by electricity supplied by flexible trailing cables. They run either on caterpillar tracks or tires and not on rails.

Each of these methods of bringing the coal from the face to the surface has its own hazards but in working sections, if the equipment is properly installed, maintained and operated, there is little to choose between them in so far as the accident incidence to operating personnel is concerned. The hand-got method requires a greater labour force, and in the main roadways the risk of accident in rope haulages is higher than on belt conveyor roads. The belts run smoothly and silently and require little attention. In rope haulages derailments of tubs lead to smashes. Persons travelling by foot between the tracks are exposed to danger from the tubs moving in opposite directions. At haulage junctions tubs must frequently be man-handled with risk to the haulage attendants.

Apart from the risks to which operating personnel are exposed, mechanized mining creates a greater degree of hazard in other respects. This arises, chiefly, from the higher capacity of the machinery. In a given time machinery produces more coal than hand-got operations would do. The greater the amount of dust created the greater the explosion and pneumoconiosis hazards. The use of machines limits the means of ventilating the bard faces to auxiliary fans—which produce certain dangers of their own, referred to in more detail later. The power requirements in a mechanized coal-getting section lead to a substantially increased risk of electrical sparking and, in this regard, damage to the trailing cables supplying the machines is a constant source of danger.

Increased risks arise, also, from the greater number of shot-holes to be charged with explosives and fired and the larger quantity of explosives stored in the coal-getting section during the shift. When machines break down their size and the distance to the outlet shaft often make their transport to the surface for repair difficult or impracticable. Welding is often necessary and, unless stringent precautions are taken, welding operations underground can all too easily cause fires and give rise to explosions. The conveyor belt roads which draw coal from the working sections are generally dustier than haulage roads equipped to take the coal out in tubs and present a greater explosion risk. The conveyor belts, if not made of flame retardent material, constitute a serious fire hazard. Wisely at No. 2 Colliery conveyor belts of **flame** retardent construction had been installed *(see, the Report, page 4).*

The mining regulations should provide that in any mine where conveyor belts are used, the belts should be made of flame retardent material.

It must not be thought, however, that we consider the increased hazards attached to mechanized mining a justification for the discontinuance of this method of mining. We emphasize, however, the need for strict supervision and control by properly trained personnel and, in mechanized mining particularly, that exacting standards must be met if safety is to be served.

Obviously, we could make no direct observation of conditions at No. 2 Colliery. The persons who were immediately concerned in maintaining standards and could have told us of them were lost in the accident. The available evidence indicates that a certain degree of laxity had crept into procedures concerned, *inter alia,* with welding operations and the use of diesel driven vehicles. Credit, however, is due to the Management for introducing a code of safety practice and issuing written directives aimed at bringing the hazards attaching to certain aspects of mechanized mining to the notice of its employees. Although long immunity from any serious accident might have blunted perception and led to deviations from the safety code it must be remembered (certainly during the years immediately preceding the disaster) that little help by way of mining regulations and Departmental supervision was given to the Management.

3.3.4. **Ventilation-**

3.3.4.1. **Mine Ventilation in general—**

The major function of mine ventilation is the dilution and dispersion of respirable dust and harmful gases from the workings. Because of its explosive properties, methane in particular has to be guarded against. It is given off by the coal itself, and it is not possible to prevent its emission. Many agencies capable of igniting methane arise from the very nature of mining operations. Despite every precaution the risk of an explosion cannot be entirely eliminated where methane is present. The primary safe-guards lie in its early detection, in providing a sufficient quantity of ventilating air to dilute it to a harmless state and to sweep it from the mine.

One of the primary considerations in the design of a mine is the quantity of air necessary to provide a safe and comfortable working environment. An estimate of the quantity must be made at the outset-

once the location of the shaft system and the layout of the main roadways have been determined and the number and disposition of the working sections to produce the desired output have been decided upon. The estimate must take into account the ventilation requirements of the mine in its various stages of development and, of course, the statutory requirements in regard to quantities, velocities and permissible content of contaminating gases and dust. It is of great importance that the estimate be as accurate as possible because on it depends the correct size of the fan, the shafts and the airways.

The proper solution of the engineering and scientific problems involved, calls for the services of ventilation specialists. If the planning is left in other hands the result is likely to be a hit or miss affair greatly prejudicing the safety of the men in the mine and substantially increasing working costs.

If a coal-mine is well planned in the first instance with centrally located shafts and a main fan of the right size, ventilation problems calling for the provision of additional upcast shafts and main fans should not arise. If the expedient of a supplementary installation has to be adopted, then more than ever are the services of the specialist required as the interconnecting of two ventilating systems could lead to complications endangering safety and not adding to it.

In investigating the reason for a mine explosion the ventilation system must come under close scrutiny as the fact of explosion implies a breakdown in the system itself. In the case of the explosion at No. 2 Colliery it was found that the layout of the workings presented a complicated ventilation picture, the details of which only the Colliery Manager could have successfully unravelled. We were not able to obtain a reliable view of the situation because certain facts relevant to the matter were not available. It would have been of great help to us if we could have heard the evidence of a qualified ventilation officer employed by the Mine.

However, an examination of plan No. L.B.W.5 *(see, appendix "**H**")* shows there were two main upcast fan shafts drawing air into the Mine through four downcast entries along an extensive series of interconnected roadways. Neither of the upcast shafts was well placed in relation to the sections of the Mine then being worked or to the areas in which work was to continue for the next eight years.

Interconnexion of the airways of a dual fan installation gives rise to a situation where, should either fan be stopped for maintenance or

repair, the action of the other might cause the ventilation current in some or other part of the *Mine* to reverse its direction. Such reversal in a working section might result in the banking up of methane at least temporarily. A greatly increased risk of explosion exists until the accumulation is dispersed.

Referring, again, to Plan No. L.B.W.5, it will be seen that in the section known as the Matura Main there was a very real danger of such a situation arising in one or other of the sets of return airways flanking the section. Apart from a reversal of flow taking place because of a fan stoppage, a reversal could have resulted if the delicate balance between the conflicting pull of the two fans was thrown out by incorrect adjustment of the regulators situated in the return airways. The Matura Main was the section where increasing quantities of methane were being detected. About three weeks before the accident the regulator controlling the return air flow from the faces comprising the right hand half of that section was adjusted to give an increased flow to those faces to relieve unpleasantly warm conditions *(see, vol. 9, page 38).*

We heard evidence, and it was not disputed, that when shot-firing was carried out in the northern part of the workings off the Bisa shafts, blasting smoke was drawn out along the intake airway past the workshops and into sections in the southern part of the Mine *(see, vol. 14, page E2).* This would not have happened had proper control of the ventilation system been maintained. It must remain an open question whether suitable control arrangements existed, and whether such arrangements might not have been adjusted in order to accelerate the clearing of smoke from where blasting had taken place.

A full time, properly qualified ventilation officer reporting directly to the General Manager of the Mine should be appointed. He should have facilities for obtaining advice and assistance from outside sources if necessary. He should be responsible for keeping ventilation plans up to date. It will be necessary for regulations to be framed in regard to these matters. Our recommendations appear in *para. 4.4, infra.*

The explosion wrecked the fan installations at the top of the two upcast shafts and cut off all mechanical ventilation. One of the fan installations---that of the Bisa Upcast—was not brought back into commission until 41 hours after the explosion in spite of herculean efforts to do so sooner. Attention is directed to the need for the fan house to be situated well clear of the mouth of its shaft, and for the airduct connecting the shaft and the fan to be constructed so as to give relief to the force of an explosion before the fan itself can be damaged. The

duct should be constructed so that if it becomes damaged it can be quickly and easily repaired.

3.3.4.2. **Sectional ventilation—**

We referred earlier to the desirability of laying out the working sections in an orderly system of panels. A panel layout is of special importance in controlling ventilation. In a properly devised system each panel forms a separate ventilation district which is supplied with fresh air by a split from the main intake air current. The air directed to the working faces then passes from the panel into one or more of the main return airways. The overall resistance of the mine to the flow of air is reduced. The possibility of air vitiated in one section, being directed to other workings is avoided. Noxious gases resulting from spontaneous heating or an active fire within a panel may be led into the return airway without affecting any other section of the mine.

The distribution of ventilating air to the various panels is controlled by regulators placed in the panel returns. Should a panel require an additional supply of air to disperse methane, or for some other reason, this can be done rapidly by adjustment of the regulator openings.

Several important advantages result from limiting the number of entries into a panel to the necessary *minimum*. Regulators may conveniently be placed in the panel returns where these airways pass through the barrier pillar. A small number of entries facilitates the sealing off of a panel when it has been worked out or when sealing is required to control a spontaneous heating or contain a fire.

We recommend, that consideration be given to requiring, by regulation, that in bord-and-pillar working the sections be laid out in panels. In this connexion the provisions of American mining legislation which refer to mechanized sections should **be studied.** *Part 75.319* of the mandatory safety standards appearing in *Federal Register No. 226 of the 20th of November, 1970,* is of particular interest.

In bord-and-pillar mining it is unfortunately true that the places most requiring effective ventilation are the places most difficult to ventilate. These places are the blind ends of the advancing stalls where coal-getting produces dust, where methane is most likely to be encountered and where the greatest number of agencies capable of igniting it are present.

The problem of ventilating the working faces has two stages. The first stage is delivery of an inflowing air current to as near the entrances

of the stalls as practicable. This stage can quite easily be met by confining the air current to one or more intake roads and preventing it from short-circuiting the return airways before it reaches the stall entrances. Short-circuiting is prevented by building brick stoppings, or erecting brattice sheets, across all roads which intersect the intake air roads and offer the air a way of escape from its predetermined course.

These measures are not necessarily easy to maintain. There is a tendency for the construction of brick stoppings to lag behind. Brattice sheets and doors make relatively inefficient stoppings, and are prone to damage when tubs or machines are taken through them. Short-circuiting then takes place.

The second stage of the problem is the delivery of a fresh current to the stall faces. *Where* the height of working is about two metres or less and hand-got methods are employed it is convenient to direct air onto the faces by suitably erected line brattices extended from the stall entrances. Where the working height becomes greater than two metres, or where mining is mechanized, line bratticing becomes too unreliable or too vulnerable to damage and should not be used. In such circumstances there is no alternative but to introduce auxiliary fans to blow air into the stalls through ventilation tubing of suitable diameter.

If the rate at which methane is emitted is greater than the rate at which it can be diffused, a build-up will result with the highest concentration at the roof. A layer of methane at the roof may spread outwards for considerable distances, and against the direction of flow of a sluggish air current. The danger of an explosion increases by extension of the gas over a wider area. A brisk air current is necessary to prevent layering. In roadways of considerable cross-section the main fan cannot, as a rule, be relied on to provide the brisk and turbulent air current required to break up roof layers. This is where an auxiliary fan, delivering air at velocity through a tube at the roof to break down layered concentrations, serves a valuable purpose.

The use of auxiliary fans to ventilate stalls would appear to be a simple and safe solution but in practice this is not so. Indeed, the operation of auxiliary fans in a fiery mine can be extremely dangerous. A number of exacting precautions must be taken in regard to the construction, capacity, location, running, restarting and maintenance of an auxiliary fan installation. If these precautions are not taken the operation of an auxiliary fan might lead to the build-up of an explosive atmosphere and might ignite it.

Several auxiliary fans were in use in No. 2 Colliery. When one of these was stopped for a comparatively short period methane in detectable quantities gathered in the stall ventilated by the *fan (see, the Report, page 13).* It is not possible to say if the stopping or misuse of an auxiliary fan contributed to the explosion but there is a strong possibility that was the case. The framing of regulations, supplemented if necessary by a code of practice, to control the use of auxiliary fans would be of major advantage in reducing the explosion hazard, and we recommend that this be done.

The detection of methane is directly related to the prevention of explosions. In order to guard against this danger, it is necessary to ensure that the percentage of methane present is well below its lower limit of inflammability. Provision must be made for work to be suspended and men withdrawn from any place where the percentage exceeds the limit prescribed by regulation.

For well over a hundred years the only practicable method available to the miner for testing for the presence of methane and estimating its content in the mine air was by observing the height of the gas cap on the flame of a safetylamp. When about 2 *per cent.* of methane is present a distinct cap is formed above the testing flame. As the lower explosive limit of methane in air is approached (that is to say, about *5 per cent.)* the gas cap increases in height and spires upwards into the gauze. When about *5 per cent.* is reached the gas explodes inside the lamp extinguishing the flame. In spite of the development of more sensitive and accurate means of testing for methane the safetylamp provides a simple and reliable method.

Efforts to produce a methanometer which can be placed in the hands of the miner as a safe, robust, simple, reliable and reasonably priced testing instrument in substitution for the safetylamp have not been entirely successful *(see, vol. 11, page P7, et seq.).* Nevertheless, such instruments as have been developed have made it possible for more rigorous safety standards (than those based on the height of a gas cap) to be imposed, and for methane alarms and recorders to be introduced.

In the Wankie field the height of working is normally such that the roof is beyond the reach of a man of average height when making a test for methane with the ordinary safetylamp. In such circumstances a methanotneter fitted with a probe of sufficient length and an aspiration bulb for a sample to be drawn from any working height, must be used. Alternatively, a ladder or set of steps is necessary for a careful and

proper test to be made with a safetylamp. The simple fact is that frequent testing for methane at the roof in working places is vital to safety. The Management must ensure, therefore, that the miners and officials have the means and facilities to enable them to carry out their duties and responsibilities so that there can be no excuse for shirking the elementary but extremely important task of testing for gas.

3.3.5. **Coal-dust explosion hazard in pillar workings—**

A general description of the coal-dust explosion hazard has already been given in *para. 1.10, supra.* Here points peculiar to pillar mining are mentioned.

In the course of primary extraction, mining proceeds on the advance, and ever increasing surfaces on the roof, floor and sides of bords are exposed. Fine coal-dust is deposited on these surfaces. The large exposed surface area makes it essential that effective dust suppression measures should immediately be taken at points where coal is drilled, cut, loaded and transferred from one means of transport to another. If this is not done the amount of stone-dust required to make the coal-dust inert becomes excessively high.

Clean mining, together with good ventilation, are the first and most important means of combating the explosion hazard. In addition, general stone-dusting is the accepted defence in most countries using pillar mining. In the United States of America, where mechanized mining originated and where it is used more than in any other country, stone-dusting is the only method of prevention required by law. The stone-dust used is some 0,25 to 1,00 *per cent.* by mass, of the coal extracted. It follows that in a large coal-mine stone-dusting is a major operation.

We recommend that consideration be given to the use of mechanical devices for applying stone-dust to roadway surfaces. If safe conditions are to be maintained samples of the dust should be monitored regularly *(cf. South African Regulations, referred to in para. 4.16, infra).*

In Britain, where pillar mining represents an almost insignificant part of all mining operations, stone-dusting must be supplemented by a stone-dust barrier in the conveyor road of each panel.

There is, then, a difference of opinion in regard to the need for stone-dust barriers. The use of barriers is discussed in some detail in para. 4.17, *infra,* where our views are set out.

3.3.6. **Use of electrical equipment—**

Every mine is to a great extent dependent on electricity for its energy requirements. In the case of a coal-mine no electrical machinery or apparatus should be introduced unless it is of flame-proof or intrinsically safe construction, and approved by an authority recognized by the Chief Government Mining Engineer for use in explosive atmospheres. It is important to realize that weak and seemingly insignificant sparks are capable of igniting an inflammable atmosphere. If the inbuilt safety of the electrical machinery is to be preserved its installation, operation and maintenance must be in the hands of well trained and competent personnel. Supervision must be comprehensive and strict.

The flexible trailing cables which provide moving machinery (such as coal cutters, loading machines and shuttle cars) with power are particularly prone to damage; they are run over and damaged and, not infrequently, are accidentally pulled apart when on full electrical load.

At the time of the disaster No. 2 Colliery had not been declared a fiery mine in terms of the Regulations. In 1966, however, the Management introduced a Code of Practice for the installation and maintenance of electrical and other equipment. This Code (having much the same effect as regulations would have had) was applied within 500 feet (150 metres) of a working face in all parts of the Mine. By regular inspection and timely maintenance it aimed, *inter alia,* at forestalling any breakdown. It was necessary, however, for oxy-acetylene flame cutting or electric arc welding operations to be carried out, from time to time, less than 150 metres from the face.

For this to be done the "written prior permission of the Mine Captain or more senior official" had to be obtained and he was required to "ensure that extensive gas tests (had) been carried out . . " *(see, Code 1, dated the 5th of March, 1971).* Although tests for methane were made where welding was to occur away from the underground workshop, there is no reference by any witness to such written permission having first been obtained.

All underground welding should be done in a properly ventilated approved workshop. When welding outside an approved underground workshop must take place, it is preferable in the interests of safety that the whole operation should be under the supervision of a mine overseer.

We believe every underground artisan and every operator of a coal cutter, coal drill or electrically driven loading machine should be able to test for inflammable gas (by means of a safetylamp and, also, by means of a methanometer) and should be equipped with these test-

ing devices. Each should be required to test while his machine is in operation; if inflammable gas is found the machine should be switched off and a report made to the miner-in-charge.

The Mining Regulations should be amended to provide for these matters.

3.3.7. **Explosives and blasting operations—**

In bond-and-pillar mining if the use of continuous mining machines is impracticable or unacceptable because of excessive dust production explosives must be accepted as normal, approved alternatives despite the hazards attendant upon their use. In the Wankie field an explosive of adequate strength is required to break the coal at the working face. Three types of explosive are permitted in fiery mines in Rhodesia — Ajax, Monobel No. 1 and Saxonite—this practice being in keeping with that in South African collieries. Permitted explosives are those which when 800 *gms.* of the explosive in the form of cartridges are charged in a shot-hole and fired, the flame produced is too short in length and duration to ignite an inflammable atmosphere *(see, section 86 of the Mining Regulations, 1961).* It must be remembered, however, that under working conditions no explosive is entirely safe in the presence of methane.

Before coal is blasted *in situ* it is provided with two free faces. This is accomplished by using a coal cutter to make a **12** to 15 *cm.* high cut to a depth of about 3 metres horizontally across the width of the coal face about midway between roof and floor. Rows of shot-holes are drilled below and above the cut. Each shot-hole is drilled 15 *cm.* shorter than the depth of the cut, charged with not more than 800 *gms.* of explosive, stemmed and, either singly or as one of **a group, fired electrically. The requirement that the coal must have two** free faces provides a reasonable safeguard against an explosive charge being overburdened and blasting out at the mouth of the shot-hole instead of breaking the coal. A blown out shot can easily ignite inflammable gas.

Blasting is one of the more usual causes of methane explosions in Southern Africa **and** few, if any, can be ascribed to anything other than human error or neglect. Defective quality of the explosive itself is very rarely a contributory cause. Bord-and-pillar working requires that a large **number of shot-holes (up to two hundred in a mechanized section) be drilled, charged with explosive, primed, stemmed and fired in the course of each shift. Each of these operations must be carried out with due regard to one or more safety precautions. During any of**

these operations errors and omissions may take place which could lead to a blown out shot and the danger of an ignition.

The incidence of methane ignitions during blasting operations proves that the cardinal error is blasting without first testing for methane or blasting when methane in a detectable quantity is known to be present. This dereliction of duty is not easy to understand and impossible to condone. It may be *due* to poor supervision but only the miner himself can ensure that it does not occur. We wish to emphasize that no matter how elaborately the precautions against a methane ignition are set out in codes or regulations the safety of a coal-mine rests essentially in the hands of the individual miner and depends on his training and sense of responsibility. The reason for this is that the source of a methane ignition which might develop into a coal-dust explosion, lies in the great majority of cases at or near the working face. It is there a single injudicious or irresponsible act in the presence of inflammable gas is most likely to give rise to disaster_ Placing the safety of a mine in the hands of an insufficiently trained and inadequately experienced miner is, therefore, the height of folly.

The importance cannot be overstressed of requiring a shift-boss or other official to visit every working face every shift, carry out tests for methane, directly supervise a representative number of blasting operations and report to the manager what he finds *(cf . section 8.9.10 of the South African Regulations, Chapter 8).*

No. 2 Colliery had not been declared a fiery mine and miners were not required to hold full blasting licences even though methane was found in the working sections. The instruction and direction given by the Management to newly recruited miners before permitting them to take charge of sections was inadequate. Before being issued with an endorsed licence for carrying out blasting in a mine where methane was being found, the applicant was examined by a Mines Department officer who had no practical experience of coal-mining. If our recommendation in *para. 5.3, infra,* is adopted, it will not be possible for such a situation to arise again.

Safety in shot-firing is increased by firing all the shot-holes comprising a round in a single operation. The individual shot-holes are timed to fire in the correct sequence by the use of milli-second delay detonators of a non-incendive type. A range of appropriately delayed detonators is chosen so that the overall delay between the explosion of the first and last shot-holes is short enough to ensure that should methane be released by one shot the danger of it being ignited by a

succeeding shot does not arise. This method reduces the possibility of a methane ignition, and avoids the necessity of the miner having to return several times to the face to blast shot-holes in their correct sequence—as he would have to do if he did not have delayed action detonators at his disposal. Exposure to blasting fumes and dust is reduced proportionately. The somewhat higher cost of non-incendive millisecond delay detonators is outweighed by the advantages to safety and health.

After a shot-hole has been loaded with explosives, stemming must be introduced to confine the charge and prevent the shot blowing out. Traditionally, sand or clay is the stemming material used for this purpose. The use of coal-dust is prohibited. The stemming of a shot-hole with sand or clay to the extent necessary to ensure that the charge will not blow out can be a laborious task taking time and, for this reason, is one likely to be skimped. In these circumstances the use of stemming ampoules filled with a water-based gel of a composition controlled to conform to specifications of water content and viscosity, greatly increases safety and saves time. The ampoule is slit near the end which will be the first to enter the shot-hole, and is pressed home against the explosives with the stemming rod. The gel extrudes and seals the hole. A single 400 *mm.* long ampoule in each shot-hole is sufficient. This type of stemming material is in widespread use in Britain and other countries with fiery collieries. It has proved effective and safe. The water content of the gel (some 95 *per cent.)* has a quenching effect on the flame produced by the exploding charge, and reduces the ignition hazard.

In bord-and-pillar mining considerable quantities of explosive are used, particularly if the operations are mechanized. Their transport, storage and distribution must be carefully organized and controlled. To promote safe distribution it might be necessary to establish an explosives transit store underground; the explosives likely to be required during the next twenty-four hours could be delivered to this point. Transport from the surface magazine to the underground store should take place between shifts when conditions are quiet and the transference can safely be made. Similarly, distribution from the underground store to the various miners' sections should take place at some safe, convenient time. Suitable storage facilities in each miner's section should be provided. Throughout their presence in the mine explosives should be either under lock and key or in responsible hands. The danger arising from the storage of explosives underground must be balanced against the danger connected with the business of transporting them underground. A mishap is more likely during transport than during

storage. Fixing a limit of twenty-four hours' probable consumption is reasonable in relation to both transport and storage; at least once in twenty-four hours conditions favourable for safe transport will exist, and there is little possibility that any deterioration of the explosives will take place during that time.

In his report Mr. Bills drew attention to certain unsatisfactory conditions as regards the storage and use of explosives at No. 2 Colliery. Explosives much in excess of twenty-four hours' probable consumption were stored in an underground magazine. This magazine was poorly sited in relation to the main intake entries. A more suitable site near the bottom of the main upcast shaft was available. Had such a site been selected any fumes arising from an incident at the magazine would have been drawn directly out of the mine and not into the workings.

The Management instructed miners to follow a set pattern and sequence of blasting the shot-holes in the coal faces. The directive required that certain charges with the heaviest burdens should be among the first to be fired *(see, the Report, pages 109 to 113).* This, in effect, was an open invitation for blown out shots to occur. The directive must be numbered as one of the more likely causes of the disaster.

3.4. **Hazards of open-cast mining in Rhodesia and their Alleviation—**

Reference to open-cast systems has been made under *para. 3.2.3, supra.*

The mining of coal by open-cast methods is a simpler operation than underground mining. Generally, the number of men at risk is comparatively small and the hazards are not as great. Nevertheless, the success and safety of an open-cast operation are dependent on a number of factors. A detailed knowledge of the geological environment and physical nature of the coal must be acquired by systematic prospecting, long range planning must be undertaken, proper equipment obtained, operating techniques must be developed and a well trained organization brought into being.

The stability of the slopes forming the sides of the excavation is a matter of prime concern to safety. Collapses of the sides of the excavations and local falls are major risks. Stability of the side-walls is affected by their height and angle of inclination, the presence of faults or slips, the strength and porosity of the several formations including the floor and the presence or otherwise of water either in the *strata* or introduced

into the excavation from outside. The proper design of wall slopes and bench dimensions is a matter for an engineer trained in soil mechanics. Drainage of the floor must be planned to conduct rain-water away from the transport roadways and from the foot of working faces and waste dumps.

Most open-cast mining involves the use of explosives. Drilling techniques, the transport of explosives and the charging and firing of blast holes must include precautions against accidental detonation through carelessness in handling or from lightning, and against the occurrence of misfires, ground tremors of damaging amplitude, fly-rock, dust and noise.

The operators of drilling machines particularly must be protected from dust caused by drilling operations. Precautions must be taken against persons or machines falling into the excavations. If work is carried out during hours of darkness adequate artificial lighting must be provided. The control of traffic into and out of the excavation requires the demarcation of set routes and procedures. Vehicle drivers must be trained and provision made for the maintenance in safe working condition of vehicles with particular regard to brakes, tires and engines. Transport roads must be kept damp to suppress dust. The operators and attendants of the machines in and about the excavation should be chosen on the basis of their natural aptitude for the task, and trained to observe safe working procedures appropriate to their duties. The machines themselves must be maintained in proper working order.

If the seam being mined or the waste material dumped back in the excavation is liable to spontaneous combustion elaborate precautions might be necessary to prevent active fires from breaking out.

We inspected the excavation when open-cast mining operations in the Wankie field were being carried out, The inspection was not of a comprehensive nature and no detailed study of the various safety aspects listed above was attempted. However, on the major aspect of slope stability the high, almost vertical faces in the highly fractured seam were considered extremely dangerous particularly at places where coal appeared to overhang the vertical.

It was observed that over sections of highwall the overburden had not been stripped in advance of the coal face. This was indicative of poor planning and supervision.

Drilling machines were raising clouds of dust. Measures for controlling the dust were either not used or were defective.

Generally an unfavourable impression was gained of the manner in which the work was being undertaken. The Commission recommends that a systematic inspection of the whole operation be carried out by mining engineers on the staff of the Chief Government Mining Engineer and that the plans of the Company for extending open-cast work be scrutinized and discussed with particular reference to safety.

In regard to the second term of reference, we summarize our conclusions in this way—

I. The regulations should require at least two separate means of egress from underground workings *(para. 3.3.1.1).*

2. Bord-and-pillar workings should be laid out in a system of panels and the number of entries to a panel through the circumscribing barrier pillar should be restricted to the *minimum* necessary to mine and ventilate the panel properly *(para. 3.3.1.2 and para. 3.3.4.2).*

3. Any workings which are not stone-dusted and which are supported by pillars of doubtful strength should be isolated by stoppings capable of withstanding an air blast resulting from a pillar collapse *(para. 3.3.2).*

4. In the layout of bord-and-pillar workings, pillar dimensions should be designed in accordance with recognized standards to ensure that unintentional collapse of the workings and surface subsidences cannot occur *(para. 3. 3.2).*

5. Any conveyor belt installed in the underground workings of a mine should be constructed of flame retardant material *(para. 3.33).*

6. A full time, properly qualified ventilation officer reporting directly to the General Manager of the Mine should be appointed. This officer should be provided with the facilities for obtaining advice and assistance and his duties should be clearly defined by regulation *(para. 33.4.1).*

7. A regulation should be introduced requiring that the siting of a mine fan in relation to the shaft it serves and the construction of the connecting duct should be such as to ensure, so far as practicable, that the fan is not damaged in the event of an explosion *(para. 33.4.1).*

8. Regulations, supplemented if necessary by a code of practice, should be introduced to control the use of auxiliary fans *(para. 3.3.4.2).*

9. The Management should ensure that persons who are required to make out tests for methane should have means at their disposal for carrying out this extremely important task with ease. *(para. 3.3.4.2).*

10. Consideration should be given to the use of mechanical devices for applying stone-dust to the roadway surfaces *(para. 33.5).*

11. If safe conditions are to be maintained, roadway dust should be monitored regularly *(para. 3.3.5).*

12. If welding operations have to be carried out underground they must take place in a properly constructed and ventilated work-shop approved in terms of regulations or, where this is not possible, under the direct and constant supervision of a mine overseer ***(para.*** *33.6).*

l3. Every underground artisan and every operator of an electrically driven machine should be able to test for methane and should be provided with the means of doing so and required to report its detection. The regulations should include appropriate provision for this *(para. 3.3.6).*

14. An examination for methane in the course of the working shift, independent of that carried out by the miner-in-charge, should be made by a shift-boss or other official. A regulation similar to section 8.9.10 of the South African Regulations, Chapter 8, should be introduced *(para. 33.7).*

15. Attention is particularly directed to our observations in regard to open-cast working *(para. 3.4).*

Chapter 4

The Third and Fourth Terms of Reference-

> ". . . in the light of the accident at Wankie No. 2 Colliery on the 6th June, 1972,, . . to inquire into and report on . .
>
> *(c) the adequacy of the provisions of the Mines and Minerals Act* [Chapter 203] *and the regulations made thereunder concerning safety in coal-miner,*
>
> *(d) any amendments to the said Act and, additionally or alternatively, regulations as may be considered advisable and necessary in the interests of safety in coalmines;".*

Each of these terms of reference should, in our opinion, be considered in conjunction with the other because if there be inadequacies in the statutory provisions, the need for amendment will be clearly shown.

There appeared to be general agreement that the existing regulations were inadequate. In Mr. Mooney's *memorandum* (to which we have already referred) this appears:

> "During my period of service I was stationed at Wankie for five years and I drafted the current Coal Mining Regulations (1961), which I considered adequate at the time. These regulations were in fact only an initial step as there were no coal mining regulations in force in the country prior to this date."

The current Regulations were published during October, **1961,** and, in so fax as coal-mining is concerned, they presumably followed Mr. Mooney's draft. When he gave evidence the Deputy Chief Government Mining Engineer told us amendments to the Act were being considered and that the task of re-writing the Regulations was well advanced. Early in November, a copy of these proposals was received by Mr. Sweeney, the Commission's Secretary. In our opinion, it will be for those entrusted with the task of settling the terms of the new legislation to add to or alter the draft in the light of such recommendations as we might make.

4.1. **Regulations relating to Coal-mines in Rhodesia—**

We recommend that the Regulations relating to Coal-mines should form a separate and distinct part of the Mining Regulations. This is

desirable so that those required to comply with them and, also, those entrusted with their enforcement will have a complete code ready to their hand.

4.2. **Fiery and Non-fiery Mines—**

We recommend that all underground coal-mines should be controlled by the same regulations. The existing distinction between fiery and non-fiery coal-mines will then disappear. An examination of the correspondence placed before Mr. Bills indicates the unsatisfactory consequences of a distinction which, at times, was difficult to maintain *(see,* the letter dated the 15th of October, 1965, from the Inspector **of** Mines, Wankie, to the General Manager of the Colliery referred to at *page 89 of the Report).* In any event, the history of mining the Wankie seam leaves one in no doubt that reportable quantities of methane will, as a matter of probability, be found in the future. It seems to us unlikely that when No. 4 Colliery starts operating, it will enjoy an immunity not shared by either No. 2 or No. 3 Colliery.

4.3. **Codes of Practice—**

During 1966 the Mine drew up a Code of Practice. It was to serve as a guide for the maintenance of flame-proof and other equipment. It was submitted to the Chief Government Mining Engineer. In his reply, the Deputy Chief Government Mining Engineer said: "The Code is a valuable guide to the management of any mine and you are to be congratulated on its preparation". *(see, the letter, dated the 2nd of October, 1966).*

At the inquiry which Mr. Bills conducted, Mr. Price, referring to this letter, said:

> "This reply indicated to us that the code was satisfactory for its intended purpose and it was implemented without any changes. We then thought that if we worked as indicated by it we would be in full compliance with the mining regulations."

(see, the Report, page 68).

After comparing the provisions of the Code and the Regulations, Mr. Bills drew attention to certain conflicts between the two *(see, the Report, pages 21 to 23).* Two other Codes were issued:

No. I dealt principally with methane, •its dangers, and the methods which should be taken to combat it. This Code is dated the 5th of March, 1971.

(see, the Report, page 108).

No. 2 Code, dated the 14th of December, 1964, dealt with "Standard Procedures — Mechanised Mining", and related to procedures connected with coal production. There is nothing to suggest that either of these was submitted to the Department.

We have given serious thought to the question whether such codes are of any real benefit to the industry. We think they are provided they do not conflict with mining regulations, deal only with safety techniques and are so framed as to serve as a practical guide to those to whom they are directed. Assuming the practices laid down are right, the value of a code must depend on whether it is followed or not. There is, we think, a good chance of its being applied if it is couched in language which will be readily understood by those whom it is sought to direct; it must not be too technical or too voluminous. It should, certainly, not be presented to the Mine's employees on the basis that it contains the only provisions to which they should conform. The Code should emphasize it is of first importance that the Regulations should be understood and applied. It should supplement the Regulations *(see,* Dr. Willett's views in regard to Codes of Practice—val. 1*1, pages M3-M5).* Copies should be issued to persons in charge of the work to which the Code relates.

We consider any Code which is for use at the Mine should first be submitted to the Chief Government Mining Engineer for scrutiny and approval Such approval, if granted, will simply imply that the Code is not in conflict with the Act or the Regulations and that it sets out safe procedures in mining practice. Code No. 2, referred to above, included instructions concerning the blasting pattern in a coal heading which were not found to be in conformity with sound mining practice *(see, vol. 9, pages 21 and 27 but cf. vol. 8, pages 79 and 80).* The administration of the Code should not form part of the duties of the Government Mining Engineer, Wankie, but should be the responsibility of the Mine itself.

4.4. Qualifications of Certain Classes of Persons Employed in Coal-mines-

4.4.1. The Mine Manager—

We recommend the adoption of this definition of manager-

" 'manager' means the person appointed to be responsible for the control, management and direction of a mine and includes the term 'general managef."

(cf. Chapter 1, Definitions, (15) of the South African Regulations). This would take the place of the definition of 'mine manager' in *section 21*

of the present Regulations. The appointment would be made in terms of *section 23.*

4.4.1.1. We recommend the adoption of *section 2.5.2.1* of the South African Mining Regulations which provides:

> "In the case of a mine in which more than 50 persons are at any one time employed underground, no person shall be appointed or bold office as manager unless he is the holder of a mine manager's certificate valid for the class of mine to which the mine belongs and issued in accordance with these regulations."

(see, Chapter 2, page 16 of the South African Mining Regulations).

When the candidate for appointment is not the holder of a Mine Manager's Certificate of Competency recognized by the Chief Government Mining Engineer, his appointment should be subject to the Chief Government Mining Engineer's approval. In that event, the Chief Government Mining Engineer should satisfy himself that the candidate's experience and qualifications are *such* as will enable him to fulfil his duties and responsibilities efficiently. We understand the Chief Government Mining Engineer recognizes Mine Manager's Certificates of Competency issued in terms of Chapter 28 of the South African Mining Regulations and, also, equivalent qualifications from other countries.

4.4.2. **Qualifications of officials subordinate to the Mine Manager—**

It will be the Mine Manager's duty to select and appoint officials subordinate to himself and to designate their duties. We cannot emphasize sufficiently the need to appoint only persons whose experience and training in the field of mining, engineering and surveying are such as to enable them to fulfil their duties efficiently.

4.4.3. **Ventilation Officers—**

We are of the opinion that sufficient attention has not, in the past, been given to the appointment by the Mine of competent Ventilation Officers whose duties should be limited to problems relating to ventilation, underground environment and explosion hazards *(see, para. 3.3.4.1, supra).*

4.4.4. **Miners or Persons in charge of Coal-producing Sections—**

Any person designated by the Mine Manager to be in charge of a coal-producing section or any part of a mine where actual mining operations are being conducted should be the holder of a full blasting

licence duly endorsed for use in a coal-mine *(see, section 11 (1), (2) and (3)* of the Explosives (Licensing and Use) Regulations, 1970). If effect is given to the recommendations set out in *para. 4.2, supra,* the need **for an endorsement in terms of** *section 11 (3)* will fall away. The Regulations will, of course, have to be amended accordingly.

4.4.5. Applicants for full blasting licences in coal-mines-

Apart from what is at present required to obtain an endorsement in terms of *section 11 (3)* of the Regulations, the applicant for a full blasting licence should satisfy the Board that he has had not less than twenty-five shifts at the working face of a coal-mine. Where the Board is satisfied of this it may endorse the licence for coal-mines. This is the kind of endorsement to which we refer in *para. 4.4.4, supra.* In addition (and this should form part of the Regulations) every applicant for a full blasting licence duly endorsed for coal-mines must satisfy the Board that he has attended at least 75 *per cent.* of the lectures and passed the prescribed examination on gases and gas testing. The lectures and examinations should be conducted by such persons as the Mine Manager may designate and should be based on a syllabus approved by the Chief Government Mining Engineer.

4.4.6. **Electricians and Artisans employed underground—**

In our opinion, it would be in the interests of safety if electricians and all artisans employed underground were required to pass the examination referred to in *para. 4.4.5, supra.*

4.5. **Repeal of section 74 of the Mining Regulations, 1%1— Section 74** reads—

> "In every coal mine an examination for inflammable gas by means of an approved safety lamp or other safety detector shall be carried out in every working place by a competent person appointed by the Mine Manager, and who is a holder of a blasting licence that has been endorsed for use in coal mines. This examination shall be carried out not more than six hours before an oncoming shift is allowed to start work in the case of non-fiery mines and not more than one hour in the case of fiery mines."

In the interests of safety we recommend that *section 74* be repealed and replaced by regulations framed on the lines of *sections 8.9.1. to 8.9.10.* of the South African Mining Regulations *(see, Chapter 8, page 46 et seq.).* We annex a copy of these provisions in the form of Appendix **`E'.**

4.6. **The scope of a Miner's duties—**

The miner is a key figure in the safe operation of a mine; if his duties are too onerous safety is bound to suffer. Mr. K. H. Saunders, the National Mining Engineer, National Union of Mineworkers of the United Kingdom, prepared a report, dated the 11th of August, 1972, which he submitted to Mr. H. **B.** Bloomfield, President/General Secretary, Associated Mineworkers of Rhodesia. At *page 10* of this report, Mr. Saunders said—

"1 note below those items of mining activity for which a miner is held directly responsible. They are extracted from a booklet titled "Wankie Colliery Company Limited: Standard Procedures—Mechanical Mining", and dated 14th December 1964:—

Cutting
Duff Lashing
Drilling, Charging and Firing
Loading
Tramming
Belt Extensions
Face Shapes
Stage Loader

Though not mentioned in this booklet, he is responsible for maintaining adequate ventilation of working places, for gas testing, for ensuring effective airborne dust control and the wetting of coal, and for the control of roof and sides.

By inference, he is required to perform manual work, to plan work schedules, to exercise close supervision over the workmen in his charge, and to accept full immediate responsibility for production at the place of work.

The nature of the miner's task is impressive, covering as it does the full spectrum of mining activity. The actual magnitude of the task in a working shift, however, is obviously related to the number of working places in his section over which he is expected to exercise direct responsible control. I understand that no direct exercise has been conducted at Wankie to determine the optimum size of a miner's section, taking fully into account the miner's responsibilities and duties.

In the interests of production efficiency (a term which accounts for production and safety collectively), I am of the view that method study should be employed in helping to determine the optimum size of a miner's section at Wankie."

In the course of his evidence, Mr. Saunders stated—

"I understand that a miner can be held responsible for **up** to, say, 20 headings. I did see in actual fact, in glancing at some miners' reports **at**

Wankie, that the miner would sign for two sections of the workings. I would like to suggest that the question should be posed as to the extent of workings which a particular miner can effectively supervise, not only in regard to operations, but also in regard to men. If you were to ask me what should be the optimum number of places, all I can say is that I do not honestly and really know at the present time, because I have no experience at Wankie. If I were to hazard a guess, I would think that a miner has a lot to do if he has six headings to look after."

(see, vol. 13, pages L2 and L3).

He was cross-examined on this matter—

"Q. You said earlier this afternoon that a miner was responsible for 20 headings?

A. He could be, I think I said.

Q. And you were unable to say what number of headings he should be responsible for, but you thought it should be something like six; is that correct?

A. Yes, I ventured that as an opinion, but I think I qualified it by saying that I would really want to spend some time myself at Wankie.

Q. That is exactly my point. So you cannot really say what the situation is?

A. No, I cannot, but I would say that it is an exceedingly important subject for consideration.

Q. But as a result of careful consideration it might come out that the present situation is satisfactory?

A. I would be surprised if that were the case.

Q. But that might happen?

A. I would still be surprised.

Q. Yes, but it might happen?

A. If you are to force me into a corner, and if I have to reply Yes or No, then I would say No; I would still say No."

(see, vol. 13, page R5).

We recommend an investigation be undertaken by Government in collaboration with the mining industry. If such an investigation is made, we recommend that *sections 2.10.3.1 to 2.1033* and also *sections 8.9.6 to 8.9.8* of the South African Mining Regulations be kept in mind *(see, Chapter 2, page 18; and Chapter 8, page 47).*

4.7. **Establishment of a Central Rescue Station—**

Certain witnesses proposed that a Central Rescue Station should be set up either at Wankie or at some other suitable place. The Rescue

Station, it was suggested, should undertake the task of training teams for rescue work in all parts of the country. It should be remembered, however, that the events of the 6th of June, 1972, were of catastrophic dimensions. Many of the persons who otherwise would have been able to take part in the rescue operations were trapped underground.

Mr. Bills examined existing facilities for rescue work and said—

"The Company also has a well equipped and well organized Rescue Station and at any time two teams can be quickly made available for underground operations. The Rescue Station is in the charge of a full time Rescue Superintendent who together with the Senior Captain was fully trained in South Africa. These two have trained or maintained the expertise of the already trained members of the Wankie Teams. The present strength is fifteen fully trained Europeans including the two team captains. The teams are trained in the use of Proto mark V and Chemox sets. As mentioned later in this report the two Wankie teams were underground within one hour of the explosion and although one team was later split up to provide guides for the outside teams one team was active throughout the rescue attempt.

In addition to the above fourteen African members are trained in the use of Proto mark IV and Chemox sets but have not been active for two years due to difficulties with the nose clips which are not suitable for the broad nostril of the average African.

A team of five other Europeans are also trained in the use of Chemox sets for surface work only in the cokeworks and by-products plant.

The rescue station has the following equipment:

(a) Two hour sets.
- (i) 26 Proto mark V.
- (ii) 16 Proto mark IV.
- (iii) 15 Aerolox.

(b) Forty five Minute Sets.
- (i) 34 Chemox.

(c) Pneolators.
- (i) 2 Minuteman type.
- (ii) 3 M.S.A. type.

(d) Oxygen Pumps.
- (i) 2 hand operated oxygen pumps.

The station also has a smoke room for simulated emergency training."

(see, the Report, page 6).

The fact that the Mine's resources were not equal to the exceptional demands which the events of the 6th of June, 1972, made upon them

is in no way a reflection on a state of preparedness otherwise wholly commendable. Mr. Price said a new rescue station was, in fact, being built *(see, vol. 8, page 35).* His views in regard to the establishment of a Central Rescue Station appear in *vol. 8 at pages 36 to 39,* and those of Dr. Willett in *vol. 11 at page K2 et seq.*

We do not, in the circumstances, feel we would be justified in recommending the establishment of a Central Rescue Station. We assume, of course, that those charged with the responsibility of organizing rescue operations will make it their business to keep in touch with the latest techniques *(see, in* this regard, Dr. Willett's remarks, *vol. 11, pages K5 to K7).*

4.8. **Accident Prevention Committee—**

An Accident Prevention Committee was established at Wankie during the time Mr. Braithwaite was General Manager of the Mine. He said—

> **"I was asked by the Mines Department to pay particular attention to this problem and in 1951 we set up the first Accident Prevention Committee and from there we developed an Accident Prevention and Safety Organization on the Colliery which I do not believe that I have seen bettered anywhere else. It was effective and it was organized so that it was not just *left* in the hands of the man at the top. The thing was delegated right down to the gang leader and supervisor level"**

(see, vol. 13, page C2).

Mr. Price spoke about the Committee's activities—

> **"There is a main committee of which I am the chairman. Represented on that committee are the heads of the Industrial Department, Personnel and Health, and certain others, No. 2 and their departments as well, down to underground manager level as far as mining is concerned. We discussed all aspects of safety, we reviewed the minutes of all the subcommittees where suggestions are made for the improvement of safety procedures, and we make recommendations to the management of the company with regard to any aspect of safety on the whole undertaking."**

(see, vol. 8, page 35).

In his report at *page* 5, Mr. Bills stated—

> **"Efforts by management to maintain safety 'awareness' is continuous and the standard safety codes laid down by the management are very comprehensive. The company employs a Security/Safety Officer and has formed a Safety Committee which meets regularly. Various competitions are organized to stimulate safety practices and general cleanliness throughout the whole undertaking."**

We consider the Accident Prevention Committee to be a thoroughly worthwhile body and the Management is to be congratulated on its formation and the useful work it has done over a number of years. It is a pity, however, that the danger of methane in association with coal-dust was not properly appreciated, *inter altos,* by those in charge of the Accident Prevention Committee.

4.9. **Contraband—**

In *paragraph 10, page 3,* of his report, Mr. Saunders said—

"I am of the view that—

(a) all persons going below at a mine, other than employees at that mine, should be effectively searched for contraband;

(b) a scheme of searching for a mine should *be* operated in such a way as to ensure that no category of employees at the mine are exempt from its provisions;"

Regulation 84 of the Mining Regulations reads—

"(l) No person shall take into the workings of a fiery mine or have in his possession in the workings of such mine any match or appliance of any kind for striking a light and no person shall smoke in the workings of the mine or have in his possession in the workings of the mine any pipe, cigar, cigarette, tobacco other than chewing tobacco and snuff, or any contrivance or material for smoking; provided that this prohibition shall not apply to the re-lighting device within an approved flame safety lamp.

(2) The Mine Manager shall appoint a person or persons to be present at the entrance or entrances to the mine or part of the mine and such persons shall ask every person about to enter the workings of the mine whether he is in possession of any of the articles pro-hibited in terms of subsection (1) of this section. The person or persons so appointed may search any person about to enter the workings of the mine for such articles.

(3) At all such entrance or entrances notices shall be posted stating that no naked lights or smoking, or smoking materials are permitted beyond such entrance or entrances."

In our view, *section 84* makes adequate provision for guarding against this danger, and no amendment is called for *(see, sections 15.11.1 of the South African Mining Regulations, Chapter 15 at page 91).* The Mine Manager must, of course, see to it that the provisions of *section 84* are carried out properly.

4.10. **Gas testing by Officials making an underground visit—**Mr. Saunders recommended that--

> "any mine official making an underground visit should always carry a flame safety lamp or methanometer and should always show a readiness to test for gas in suspect places."

(see, page 4 of his report).

We have considered this recommendation but think our proposals in regard to gas testing provide a sufficient safeguard *(see, para. 4.5, supra,* and the proposed incorporation of Appendix `E').

4.11. **Self-rescuers---**

Mr. Saunders recommended-

> "Self-Rescuers be provided for personnel at Wankie either as a condition of employment or as a statutory requirement."

(see, page 4 of his report).

The evidence placed before us suggests self-rescuers have a limited application and we do not think this recommendation by **Mr.** Saunders should be acted upon *(see, Dr. Willett's report, page 12,* and his evidence in confirmation, *vol. 11, page G7).*

4.12. **A Two-token Checking System—**

Mr. Saunders made certain recommendations in this regard *(see, his report, page 4).*

Mr. Livingstone-Blevins described the system of checking used at Wankie *(see, vol. 7, pages 60 and 61),* It seems to us to be satisfactory and we do not recommend any alteration.

4.13. **Introduction of Garforth-type Safetylamp-**

in his report Mr. Saunders said he considered it essential this type of lamp should replace the safetylamps at present in use at the Mine *(see, page 5 of his report).* This matter was examined when Dr. Willett gave evidence *(see, vol. 11, page P7 et seq.).* His views *were* put to Mr. Saunders who did not, when he gave evidence, appear to be quite as definite in regard to the need for change as when he prepared his report *(see, vol. 13, page N2 et seq.).* We do not think it desirable at this time to insist upon the replacement of the safetylamps in use at the Mine with lamps of the Garforth-type.

4.14. **Technical Information and its dissemination—**

Although this does not fall within the third or fourth term of reference we consider it desirable to express our views on the matter. Mr. Saunders said-

> ". within recent years a programmed lecture titled 'Firedamp' was drawn up by the Safety in Mines Research Establishment, suitable for presentation to the whole cross-section of the mining force.
>
> It is concerned with the developing knowledge of this inflammable gas, its mode of occurrence and participation in the more recent explosions. The lecture is very well illustrated by films and liberal use is made of excellent demonstration apparatus.
>
> It has proved to be a first class educational medium, and has been well attended and reported upon by large audiences throughout all the coalfields.
>
> I would recommend that the lecture, together with associated films and demonstration apparatus (or design and operational data) be secured for the mining force at Wanlde."

(see, pages 6 and 7 of his report).

We agree with this recommendation. The Ministry of Mines and the Chamber of Mines should constantly be on the look-out for literature (including films) of an educational and instructive character relating to coal-mines. Once such literature is found, they should immediately bring it to the attention of the Mine Management. The Department of Mining Engineering, in particular, should spare no effort to inform itself of current literature in regard to mining techniques and safety procedures. It was with feelings of surprise we learned that certain senior officials in the Department and, for that matter, at the Mine only became aware after the disaster of the existence of such authoritative publications as *the Report, 1961, and the Final Report, 1967;* both publications were issued by **the** National Coal Board, London *(see vol. 1, pages D10 and D11; vol. 5, pages 39 and 40; vol. 7, pages 11 and 12;* and *vol. 8, page 10).*

4.15. A System of Workmen's Inspectors—

We have considered what Mr. Saunders had to say in this regard *(see, page 8 of his report).* We are sure the system has great merit in the United Kingdom. With the conditions prevailing at Wankie, however, we think sufficient opportunity exists for the communication of complaints in regard to safety, health protection and unsafe mining practices.

4.16. The Establishment of Airborne Dust Standards in the interest of health—

Mr. Saunders said—

> **"I propose that Airborne Dust Standards should be established at Wankie and that Airborne Dust Control should be a subject for which the Ventilation Engineer should have a specialistic responsibility."**

(see, page 13 of his report).

There does not appear to be general agreement on what would constitute satisfactory Airborne Dust Standards. That being so, we do not think this is the time to lay down arbitrary standards. We understand reports of airborne dust are made from time to time by the Ventilation Officers employed in the Department of Mining Engineering; if anything abnormal is found the Pneumoconiosis Board is advised. In such cases the Board calls for a re-examination of the air conditions in the mine. Facilities exist, then, for checking airborne dust in a mine. If these facilities are properly used (and we have no reason to suppose they are not) safe conditions can be maintained.

Section 10.9.4 **of the South African Mining Regulations** *(see, Chapter 10, page 66)* **reads—**

> **"In every coal mine measurements shall be made during the main working shift not less than once in six months or at such intervals as the Government Mining Engineer may permit of the amount of dust in the air in representative working places in each section while drilling, cutting, breaking, loading or transfer of coal or rock is taking place."**

We recommend that a provision on similar lines should be incorporated in the Rhodesian Mining Regulations.

4.17. Coal-dust Explosion Prevention—

We recommend that *sections 10.24.1 to 10.24.8; 10.24.10 and 10.24.11* **of the South African Mining Regulations should be incorporated in the Rhodesian Mining Regulations** *(see, Chapter 10, pages 71 et seq.).* **These** *sections* **deal with compulsory stone-dusting in South African coal-mines. We annex a copy of these sections as Appendix 'F'.**

Section 10.24.9 **reads—**

> **"Stone dust barriers erected for the purpose of suppressing a coal dust explosion shall be of a design and construction approved by the Inspector of Mines and located at such points as the manager, after consultation with the Inspector of Mines, may determine."**

This provision does not make the erection of stone-dust barriers compulsory. The three Members of the Commission take the view the matter should be left in that form; their reasons are—

The premise that the conveyor road represents a special danger from the point of view of coal-dust explosions is accepted. It is also accepted that stone-dust barriers constructed at specified distances along the conveyor roads in mines adopting the longwall method of mining (as is generally the case in Britain) are of value. However, the efficacy of these barriers in mines using the bord-and-pillar system is doubted.

In the case of bord-and-pillar mining systems where the conveyor road is flanked by other roads either in direct communication with it or separated from it by stoppings which are not explosion proof, there is a very real possibility of a stone-dust explosion extending itself in the flanking roads.

The effectiveness of a stone-dust barrier depends critically on its position with respect to the point of possible ignition *(see, para. 1.10, supra).* In bord-and-pillar mining the possible point of ignition cannot be anticipated with any certainty and, therefore, the most suitable position for a stone-dust barrier must remain a matter of mere conjecture.

To their knowledge no experiments have been carried out in bord-and-pillar workings or in galleries simulating pillar workings *(see, para. 3.3.5, supra)* to check the effectiveness of stone-dust barriers. Thus, there is no evidence to justify making their installation mandatory. In fact, in the United States of America, the country where the bord-and-pillar system is employed on the largest scale, the efficacy of stone-dust barriers is doubted, and there they are not a compulsory requirement.

If management is prepared to undertake the expense of barrier installation, the logical sites for stone-dust barriers would be where a conveyor road enters a panel through its barrier pillar and at points along the trunk conveyors out-bye of the delivery points of branch conveyors.

They are, therefore, in favour of leaving the relevant stone-dusting regulation-10.24.9 of the South African Regulations—as it stands.

The Chairman, however, is equally firm in his belief that the erection of stone-dust barriers should be a statutory requirement. The balance between cost and risk, the efficacy of barriers in arresting explosions in bord-and-pillar mines and the other factors which were

referred to by Dr. Willett leave him in no doubt that their erection should not be in the discretion either of the Mine or the Department of Mining Engineering. It was only after considerable hesitation it was decided to use them in the United Kingdom. On the 1st of October, 1960, however, their erection was required by law *(see, vol. 11, page F5 et seq.; vol. 12, page Al et seq.).* At *page B3, vol. 12,* Dr. Willett said—

> "In my view it is quite clear that stone-dust barriers will stop an explosion on a coal conveyor road and research and experience have shown that stone-dust barriers are not necessary in a roadway where there is no coal conveyor."

(see, vol. 12, page F2, and *see,* generally, *the Report 1961).* The Chairman is also of the opinion that even if costly, the presence of stone-dust barriers will go a long way to convince employees that the Management is doing everything which is reasonably possible to ensure their safety *(cf.* Mr. Mooney's remarks in *para. 7* of his first *memorandum* and, also, in his second *memorandum).*

4.18. General—

We have drawn attention to those matters which, in our opinion, call for urgent amendment. And we include, of course, those referred to in our consideration of the second term of reference *(see, Chapter 3 supra).* There are, however, a number of topics of varying degrees of importance which cannot be dealt with in this report. We have not, for example, made a detailed examination of the Mining Regulations, 1961. We have not done this because both the Department of Mining Engineering and the Management were of the opinion that they were wholly inadequate and in need of drastic revision—an opinion with which we agree. As we have pointed out, a comprehensive survey of the Act and the Regulations is being undertaken by the Ministry. We understand that in the performance of this task, it has taken account of the Mining Regulations of the Republic of South Africa, of the United Kingdom and of other countries. We consider it most important that this legislation should be the subject of careful study so that nothing is overlooked.

In regard to the third and fourth terms of reference, we summarize our conclusions in this way-

1. We recommend that regulations relating to coal-mines form a separate and distinct part of the Mining Regulations *(para. 4.1).*

2. We recommend that all underground coal-mines should be controlled by the same regulations. The existing distinction between fiery and non-fiery mines will then disappear *(para. 42).*

3. Subject to the qualifications set out in *para. 4.3, supra,* we consider that Codes of Practice which deal with safety techniques and are so framed as to serve as a practical guide, are of real benefit to the mining industry *(para. 4.3).*

4. We recommend the adoption of the definition "manager" in the South African Mining Regulations, Chapter 1, Definitions (15) *(para. 4.4).*

5. We recommend certain qualifications in the case of—

   Mine Manager;
   Officials subordinate to the Mine Manager;
   Miners or persons in charge of coal producing sections;
   Applicants for full blasting licences; and
   Electricians and Artisans employed underground

   (para. 4.4).

6. We recommend that more attention be given to the appointment by the Mine of competent Ventilation Officers whose duties should be limited to problems relating to ventilation, underground environment and explosion hazards *(para.* 4.4).

7. We recommend that *section* 74 of the Mining Regulations, 1961, be repealed and replaced by regulations framed on the lines of *sections 8.9.1 to 8.9.10* of the South African Mining Regulations, Chapter 8 *(para. 4.5).*

8. We recommend that Government in collaboration with the Wankie Colliery Company, Limited, undertake an investigation into the scope of a miner's duties *(para. 4.6).*

9. We do not recommend the establishment of a Central Rescue Station. The fact that the Mine's resources were not equal to the exceptional demands which the events of the 6th of June, 1972, made (upon them is in no way a reflection on a state of preparedness otherwise wholly commendable *(para.* 4.7).

10. The Mine is to be congratulated on the formation of an Accident Prevention Committee and the useful work it has done over a number of years *(para. 4.8).*

11. *Section 84* of the Mining Regulations, 1961, makes adequate provision for guarding against the danger of contraband being taken underground *(para. 4.9).*

12. If the recommendation set out in *para. 4.5 supra is* implemented there would, in our opinion, be no need for gas testing by officials making an underground visit *(para. 4.10).*

13. We do not recommend the compulsory use of self-rescuers *(para. 4.11)* or the adoption of a two-token checking system *(para. 4.12)* or the introduction, at this time, of the Garforthtype safetylamp *(para. 4.13)* or a system of Workmen's Inspectors *(para. 4.15).*

14. The Ministry of Mines and the Chamber of Mines should be on the look-out for literature (including films) of an educational and instructive character relating to coal-mines. When such literature comes to their notice, they should immediately notify the Mine Manager. And the Department of Mining Engineering should spare no effort in informing itself of current mining techniques and safety procedures *(para. 4.14).*

15. While we do not think the time is right for the laying down of Airborne Dust Standards, we recommend that a provision similar to *section 10.9.4* of the South African Mining Regulations, *Chapter 10,* be introduced *(para. 4.16).*

16. We recommend the adoption of *sections 10.24.1 to 10.24.8* and *10.24.10* and *10.24.11* of the South African Mining Regulations, *Chapter 10.* These *sections* make stone-dusting compulsory in coal-mines. The Commission is divided, however, on the question whether the erection of stone-dust barriers should be made compulsory *(para. 4. 17).*

Chapter 5

The Fifth Term of Reference-

". . . in the light of the accident at Wankie No. 2 Colliery on the 6th of June, 1972, . . . to inquire into and report on . . .

(e) *whether the supervision of mines exercised by the Ministry of Mines in terms of the said Act and regulations is adequate, and, if not, in what respects it should be improved in the interests of safety."*

5.1. **Establishment of the Department of Mining Engineering—**

Upon inquiry we learned that the Department of Mining Engineering was established and acts in terms of *section 373 (d)* of the Mines and Minerals Act *[Chapter 203]* (but, *see*, also *sections 253, 372 and 417 (3) of the Act).* It is difficult, however, to put one's finger on any provision which deals specifically with the supervision and safety of mines. We recommend that the Act be amended to include a provision similar in terms to *section* 2 of the South African Mines and Works Act, 1956, as substituted by *section 2* of Act 42 of 1968.

Section 2, as amended, reads:

"The Government Mining Engineer and, subject to his directions, the Deputy Government Mining Engineers, Assistant Government Mining Engineers, inspectors of mines, inspectors of machinery and other officers appointed or deemed to have been appointed for the purpose under *section* 3 of the Mining Rights Act, 1967 (Act No. 20 of 1967) shall exercise supervision over all mines, works and machinery."

Section 3 of the Mining Rights Act states—

"(1) The Minister shall, subject to the laws governing the public service—

(a) appoint a Government Mining Engineer and a Director of the Geological Survey who shall respectively exercise the powers and perform the functions and duties conferred or imposed upon them by this Act or any other law, and such other powers, functions and duties as may be conferred or imposed upon them by the Minister under this Act;

(b) appoint inspectors and other officers and employees who are in his opinion suitably qualified for the purpose, to assist the Govern-

ment Mining Engineer in the exercise of such powers and the performance of such functions and duties;

(c) in respect of every mining district, appoint a mining commissioner or designate an officer or employee in the public service who shall in addition to his other duties exercise the powers and perform the functions and duties which in terms of this Act or any other law are required to be exercised or performed by a mining commissioner;

(d) appoint claim inspectors to assist any mining commissioner or any officer or employee designated to exercise the powers and perform the functions and duties of a mining commissioner.

(2) A mining commissioner shall, within the mining district for which he has been appointed, exercise the powers and perform the functions and duties specially conferred or imposed upon him by this Act or any other law, and such other powers and duties as may be conferred or imposed upon him by the Minister under this Act.

(3) Any person holding at the commencement of this Act any office referred to in subsection (1) shall be deemed to have been appointed under this Act."

It will be necessary to introduce a provision similar to *section 3.* We suggest the deletion of the reference to "inspectors of machinery" and, also, the concluding words "works and machinery". And we recommend that the provisions of *sections 3, 4, 5 and 6* of the Mines and Works Act, 1956, be included in the Rhodesian Act. These *sections* deal with the "General Powers of Inspectors and Officers" *(section 3),* "Jurisdiction of Inspectors to try certain offences, and appeals against findings or sentences" *(section 4),* "Inquiries into accidents and other matters" *(section 5)* and "Attendance and examination of witnesses at trials and inquiries". *(section 6).*

5.2. **Supervision at Wankie-**

We understand this term of reference to refer specifically to supervision at Wankie at the time of the disaster, not to supervision by the Ministry of Mines in other areas.

For many years, a Government Mining Engineer has been resident at Wankie. However, before the appointment of the present incumbent in 1969, the difficulty of securing suitable staff resulted in the post being left vacant for about 18 months *(see, vol. 1, page A13 and page C2).*

The duties of the Government Mining Engineer stationed at Wankie covered three fields of activity—mining engineering, mines' inspection

The President, the Honourable Clifford W. Dupont, I.D., President in and over Rhodesia, Commander-in-Chief of the Armed Forces of Rhodesia and Grand Master of the Legion of Merit.

INTRODUC1 ION

Sir,

By a commission issued on the 4th of September, 1972, we were required ". . . in the light of the accident at Wankie No. 2 Colliery, on the 6th June, 1972, . . to inquire into and report on the following matters—

(a) any question arising out of or connected with the said accident, which, in the opinion of the Commission, has not been adequately covered by any other investigation;

(b) the principal systems of coal-mining practised in Rhodesia, with special reference to safety;

(c) the adequacy of the provisions of the Mines and Minerals Act *[Chapter 203],* and the regulations made thereunder concerning safety in coal-mines;

(d) any amendments to the said Act and, additionally or alternatively, regulations as may be considered advisable and necessary in the interests of safety in coal-mines;

(e) whether the supervision of mines exercised by the Ministry of Mines in terms of the said Act and regulations is adequate, and, if not, in what respects it should be improved in the interests of safety."

The Commission comprised:

Chairman: The Honourable Sir Vincent Quenet, Q.C.;

Members: Mr. Charles Henry Chandler, I.C.D., C.Eng., F.I.M.M., F.R.I.S.;

Dr. Miklos DersO Gyorgy Salmon, Ph.D., Dipl.Ing.(Min.) (Hungary), F.S.A.I.M.M.; and

Mr. Albert Duncan Vos, B.Sc.Eng.(Min. & Met.) Rand, F.S.A.I.M.M.

Before our appointment, an advertisement appeared in the *Government Gazette,* the *Rhodesia Herald,* the *Bulawayo Chronicle,* the *Sunday*

Mr. Davey said

.we have always played it that the man on the spot can ask for whatever he wishes."

(see, vol. 1, page C5).

Mr. Davey was asked—

"Did he receive any instructions from your Head Office or from the Regional Mining Engineer at Bulawayo, as to the manner in which he should carry out his functions?"

He replied—

"Yes, this was when he was appointed. I wrote, saying: 'Go to Bulawayo for a few weeks to get the hang of the procedure of the office.' In fact I think the last incumbent, or the present incumbent, at Bulawayo was working the other way. The Engineer from Bulawayo came up and spent some time with him at Wankie."

His evidence continues in this way:

"Q. You cannot say what these instructions were; what form they took?

A. No, I cannot tell you what transpired between the Engineer from Bulawayo and the local Wankie member.

Q. They were simply to advise him of the manner in which he was to fulfil his responsibility as Mining Engineer-in-charge?

A. That is correct.

Q. Are you able to say whether they would relate principally to ensuring that the Regulations were properly implemented, or would they go beyond that?

A. It would have covered all the facets of his job.

Q. But there was no direction from Head Office as such that you know of?

A. Except that when recruits are interviewed at Head Office their duties are discussed with them.

Q. These duties are not set out in any pamphlet? A.

Not in any particular pamphlet."

(see, vol. 1, pages A14 to A15).

Further on in his evidence, this appears-

"Q. He was quite alone at Wankie? He was the only representative of your department?

A. Yes, your worship.

Q. I am not talking about the typist?

A. No. But if there were any duties which he wanted done in addition or which he felt he could not cope with, he could ask the Bulawayo office for help, such as surveying, anything in this line. He would then call on the resources of the Bulawayo office.

Q. Can you say whether that happened or not?

A. He must have, I think, called on the services of a surveyor from time to time for the other mines, not necessarily Wankie.

Q. When it came to reaching a decision in regard to a matter about which he himself felt some doubt, would he consult with anybody?

A. All he had to do was to ring the Bulawayo engineer, the regional engineer, discuss it either over the 'phone or ask to come down or for the engineer to come up."

(see, vol. 1, pages B7 and B8).

At *page C4* of his evidence, **Mr.** Davey said—

"If our district officers are worried about, say, a ventilation problem or a mechanical problem in their area they just ask to have the services of the appropriate man.

Q. Then you are thrown back to the man on the spot? A. To

a large extent, yes.

.....

"If you try and regiment a department such as ours I am afraid that you would tend to work to a book of rules rather than the man using his initiative, and we have always played it that the man on the spot can ask for whatever he wishes.

Q. But oughtn't there to be some general guide lines for him to pursue or is it your view that the guide lines are set out in the Act and in the Regulations?

A. He certainly has the Act and the Regulations to guide him from the inspector's side. This is quite clear.

Q. But apart from that there is nothing?

A. There is nothing except he knows the general policy of the Government and of the Ministry and the duties vary so much that if you adopted the procedures of giving a man in a particular post instructions you would have to more or less give instructions for every post because your districts vary ..."

(see, vol. 1, page C5).

4.16. **The Establishment of Airborne Dust Standards**

health—

Mr. Saunders said—

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specialistic respo Ventilation Engineer should have a

(see, page 13 of his report).

AND/OR

(b) a Mine Manager's Certificate of competency in coal-mining, issued in terms of Chapter 28 of the South African Mining Regulations *(see page 150 et seq.)* or a certificate (issued by some other country) acceptable to the Chief Government Mining Engineer.

We draw attention in this regard to the provisions of *section 15* of the Explosives (Licensing and Use) Regulations, 1970, and, also, to sections 28.13 and 28.14 of the South African Mining Regulations *(see Chapter 28, pages 150 and 151).*

During his first four years, the incumbent at Wankie should carry out systematic inspections of the Mine at least once a year. A detailed report of such inspections should be prepared by him for submission to the Regional Government Mining Engineer, Bulawayo. Our reason for making this recommendation is that we believe it to be of the greatest importance that the incumbent should become thoroughly familiar with conditions at the Mine. We consider, also, that for a period of not less than three months after his appointment (and before taking up his duties at Wankie), he should be attached to the office of the Regional Government Mining Engineer, Bulawayo, and under his close supervision.

We are of the opinion that the inspections of the Mine by the Government Mining Engineer, Wankie, should be supplemented by inspections by the specialist engineers attached to the Department of Mining Engineering. And we are not referring here to the technicians assigned to various districts. The duties of the Government Mining Engineer, Wankie, are sufficiently diverse to call for specialist supervision in the fields of ventilation, surveying and mechanical and electrical engineering. Such inspections should be undertaken at least once every two years and reports should be submitted to the Chief Government Mining Engineer as soon as possible after the inspection has been made.

Ideally, the Government Mining Engineer, Wankie, should not live at the Mine itself. We say this because residence there might result in a too close involvement in the life of the community—by no means a bad thing in itself, but in the case of some individuals a situation which might lead to embarrassment when compliance with the Regulations is sought to be enforced *(see, Mr. Bills' views, vol. 6, pages 32 and 33).* It seems to us, however, it would be unrealistic to insist he should live elsewhere or be attached to the office of the Regional Government

Mining Engineer, Bulawayo. His duties make it necessary for him to be within comfortable distance of the Mine itself. It is for the incumbent to see he maintains a position of independence in the community.

5.4. **Standing Orders—**

We have already drawn attention to that part of Mr. Davey's evidence which reads—

> "If you try and regiment a department such as ours, I am afraid you would tend to work to a book of rules rather than a man using his initiative, and we have always played it that the man on the spot can ask for whatever he wishes."

(see, vol. 1, page C5).

And his further observation on the same page-

> ". . . the duties vary so much that if you adopt the procedure of giving a man in a particular post instructions, you would have to, more or less, give instructions for every post because your districts vary. They may consist of entirely large mines, or almost entirely large mines, or, on the other hand, entirely small mines."

We do not think these considerations provide a sufficient reason for not issuing standing orders. Whatever might *be* the position in other districts, we are in no doubt so far as Wankie is concerned there should be such standing orders. If such standing orders are issued, the illcumbent will know from the outset what is expected of him. They should be drawn up by the Department and should cover the incumbent's duties in the fields of mining engineering, mines' inspection and the licensing and use of explosives. They should also, deal with the holding of inquiries, attendance at trials and the compilation of reports.

5.5. **General—**

At *page 15* of his report, Mr. Saunders said—

> "Salary levels and status levels are related and, in any case, the remuneration of Inspectors should *be* such as to attract the best men from the senior managerial ranks—to provide a better guarantee that the best advice and guidance will be given and heeded."

In regard to this expression of view, we intend to say no more than that the Ministry of Mines should be vigilant to see the conditions of service are such as to attract persons of the requisite training and experience to positions in the Department of Mining Engineering.

In regard to the fifth term of reference, we summarize our views in this way-

1. We recommend the introduction of a section similar to section *3* of the South African Mining Rights Act, 1967 *(para. 5.1).*

2. We recommend that the Act be amended to include a provision similar to *section 2* of the South African Mines and Works Act, 1956, as substituted by *section 2* of Act 42 of 1968 *(para. 5.1).*

3. We recommend that the provisions of *sections* 3, *4, 5 and 6* of the South African Mines and Works Act, 1956, be included in our Act. These sections deal with the "General Powers of Inspectors and Officers", "Jurisdiction of Inspectors to try certain offences and appeals against findings or sentences", "Inquiries into accidents and other matters", and "Attendance and examination of witnesses at trials and inquiries" *(para. 5.1).*

4. The supervision at Wankie at the time of the disaster was not adequate. Our reasons for this finding appear in *para. 5.2.*

5. We recommend certain *minimum* qualifications for the post of Government Mining Engineer, Wankie, and the inspections which he and the specialist engineers attached to the Department should be required to *make (para. 5.3).*

6. Standing orders should be issued to the incumbent of the post of Government Mining Engineer, Wankie. They should be drawn up by the Department and should cover the incumbent's duties in the fields of mining engineering, mines' inspection and the licensing and use of explosives. They should, also, deal with the holding of inquiries, attendances at trials and the compilation of reports *(para. 5.4).*

7. The Ministry of Mines should be vigilant to see the conditions of service are such as to attract persons of the required training and experience to positions in the Department of Mining Engineering *(para. 5.5).*

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APPENDIX 'A'

Persons who submitted Memoranda

Mr. K. G. L. Clayton

Mr. J. C. Ferguson

Mr. W. Finlay

Mr. D. Frost

Mr. R. M. Mooney, BSc.

Mr. G. J. P. Noppe

Mr. K. H. Saunders, B.Sc. (Min.), M.I.Min,E., C.Eng.

APPENDIX 'B'

Persons who gave Evidence before the Commission

1. Mr. G. Acheson
2. Mr. D. J. V. S. Almond
3. Mr. L. Bills, B.Sc.(Min.), A.I.Min.E.
4. Professor G. Bond, O.L.M., B.Sc.(Hon.), Ph.D., A.R.C.Sc., C.Eng., F.I.M.M., F.G.S., F.G.S.(Am.)
5. Mr. T. A. J. Braithwaite, B.Sc.(Hon.)(Min.), F.I.M.E., C.Eng., F.I.M.M.
6. Mr. A. Butterworth
7. Mr. D. L. R. Coetzee
8. Mr. I. M. Cowan, A.C.I.S.
9. Mr. B. Davey, A.C.S.M., F.I.M.M.
10. Mr. W. Finlay
11. Mr. D. P. C. Hepburn
12. Mr. S. A. Z. Liedberg B.Sc.(Min.) (Stockholm)
13. Mr. G. J. Livingstone-Blevins, F.S.A.I.M.M.
14. Mr. W. B. Lyon, B.Sc.(Min.)
15. Mr. W. T. A. Marshall Goodridge

16. Mr. J. J. Murphy
17. Mr. G. J. P. Noppe
18. Mr. L. A. Price, F.I.M.E.
19. Mr. J. Robinson
20. Mr. K. H. Saunders, B.Sc.(Min.), M.I.Min.E., C.Eng.
21. Mr. H. Smith, B.Sc.(Min.), F.S.A.I.M.M.
22. Dr. J. G. N. Stagman, D.Sc.
23. Mr. B. J. van der Merwe
24. Mr. T. Wharren, B.Sc.(Min.)
25. Dr. H. L. Willett, O.B.E., D.Sc.(Eng.), Ph.D., B.Sc.(Min.), C.Eng., F.I.Min.E., M.I.C.E., F.G.S.

APPENDIX

A Brief Account of Coal-mine Explosions in Southern Africa 1. Historical Note

1.1. In Britain the first recorded ignition casualty was in 1621, and the first known reference to the possibility of coal-dust being explosive was made towards the end of the 17th century.

In 1880 the use of water and stone-dust were first mentioned as precautionary measures against coal-dust explosions. After an explosion at the Seaham Colliery, it was found that intake travelling roads driven partly in stone were not damaged; damage, however, was noticed in the case of the parallel haulage roads which had been driven through coal.

In 1908 a Royal Commission recommended that the combustible properties of coal-dust could be destroyed by watering-down or by mixing salt or an inert dust with coal-dust. In consequence of the Commission's report the Mining Association of Great Britain appointed a committee under the chairmanship of Sir William Garforth to carry out experimental work in an explosion gallery at Altofts.

In 1920 general regulations were introduced in Britain requiring a *minimum* of 50 *per cent.* incombustibles or 30 *per cent.* moisture in roadway dust. In 1939 the 50 *per cent.* incombustibles figure was increased to 65 *per cent.*

1.2. In South Africa, at the time of Union (1910), the mining regulation concerned with the coal-dust hazard read—

> "65. In dry coal mines such parts thereof shall be kept well watered, as may be directed by the Inspector of Mines. The Inspector of Mines shall decide whether a mine is to be considered a dry mine."

In 1913 this regulation was repealed and replaced by a new regulation, *para. 3 (a)* of which read—

> "In any coal mine, not exempted by the Inspector of Mines, every main haulage road and every main intake airway shall be protected from coal dust explosion by adequate watering, stonedusting, or other protective measures approved by the Inspector of Mines."

This regulation was amended in 1930 to bring it into line with coincident legislation in Britain. The amendment required, among other things, that a 50 *per cent.* incombustibles standard of stone-dusting should be maintained to within 30 feet of every working face. Water was still recognized as acceptable and the standard set for watering was a 30 *per cent.* by weight moisture content.

In 1938 an amendment empowered the Inspector of Mines to set a higher standard of incombustible content than 50 *per cent.* In 1964 the regulation was again amended to incorporate a schedule relating the standard of stone-dusting to the volatile content of the coal being mined. Watering was no longer recognized as an alternative precaution to stone-dusting, and provision was made for the Inspector of Mines to call for stone-dust barriers.

2. **Explosions in Rhodesian Coal-mines other than the 1960 and 1970 ignitions and the Explosion of the 6th of June, 1972—**

Only one such incident is on record. This took place on the 5th of January, 1962, at the Bubye Coal Prospect, some 90 *kin.* east of Beitbridge. A methane explosion in a vertical prospect shaft caused the death of 11 persons. The shaft had been sunk to a depth of 101 metres for the purpose of obtaining a bulk sample from the coal seam. In the course of being sunk, the shaft passed through a number of lesser seams which were giving off methane. The shaft was ventilated by a fan on the surface, air was blown into the bottom through plastic ducting. In the course of the first blast in the coal seam to break out the sample, a minor methane explosion took place damaging the shaft and putting its signalling system out of commission. About half-way up the shaft the ventilation ducting was twisted and burst by the force of the explosion. The fan was stopped so that repairs could be undertaken.

It was while repair work was in progress that a second and more severe explosion took place killing everyone in the shaft. Apparently the ignition was caused by a match struck by one of the workmen stationed on the shaft ladderway.

3. **South African Coal-mine Explosions**

3.1. **Natal**

The earliest record of a fire-damp ignition was in 1891 at the Elands-laagte Colliery in Natal. An African workman was fatally burned.

In 1899 an explosion at Natal Navigation Colliery claimed 31 lives. It was probably caused by the introducton of a naked flame into firedamp which had gathered in poorly ventilated workings.

In 1906 in a section at Elandslaagte an unsuspected accumulation Of fire-damp extinguished all the flame safetylamps except one. When this lamp was opened to relight the others an explosion resulted, killing 18 men.

In February, 1908, the danger of coal-dust was brought home with tragic force. A shot-hole fired in a stall in the Glencoe Colliery in Natal blew out and ignited methane. The burning methane set brattice cloth alight and the fire spread to timber and coal. No fire-fighting facilities were immediately available. Unsuccessful attempts were made to restrict the fire. A series of minor methane explosions took place and these culminated in a coal-dust explosion which wrecked the mine and killed the 77 persons (including an Inspector of Mines, Mr. Muir), who were engaged in sealing and rescue operations.

In June, 1908, a practically identical set of circumstances arose in the nearby Cambrian Colliery where, again, a blown out shot ignited fire-damp which set alight brattice, timber and coal. When it became apparent the fire could not rapidly be extinguished or closely confined, all persons were withdrawn from the mine. A series of minor explosions followed and, finally, a great coal-dust explosion swept through the mine.

The next year the Inspector of Mines arranged for bulk samples of coal from Natal to be sent to the testing gallery at Altofts **in** Britain. These tests confirmed that the dust from bituminous coal in Natal was explosive. Sir William Garforth suggested the use of stone-dust. Pressure on the mines led to progress in that direction but supplies of suitable stone-dust were not readily available and water had not been laid on

the fan was restarted the moving body of inflammable gas encountered some or other incendive agency. The resulting explosion killed 15 men. The mine was stone-dusted. The explosion and its effects were confined to a single section.

In 1943 at Northfield Colliery an insufficiently tamped shot-hole was blasted in an unventilated stall which had filled with fire-damp. The shot blew out and a violent explosion resulted. Coal-dust in the section contributed locally to the explosion but the workings were stone-dusted and the explosion did not advance further through the mine. Nevertheless 78 men were killed, the majority from the effects of carbon monoxide in the afterdamp.

In 1944 at Hiobane No. I Colliery 57 men were killed in a methane explosion, after a miner had forced open his safetylamp to adjust the relighter mechanism which he thought was defective. He struck a spark before screwing the parts of the lamp together again and set off an explosion. The mine was well stone-dusted and the explosion did not spread out-bye of the miner's section.

In 1951 at Durban Navigation No. 2 Colliery nine men were killed in a methane explosion caused by a blown out shot. The miner failed to carry out a test for fire-damp before blasting. The mine was well stone-dusted and coal-dust played no significant part in the incident.

In 1962 at the Northfield Colliery a shot which blew out into the goaf in a pillar extracting section, caused a methane explosion which killed 10 men. The mine was stone-dusted and the explosion did not spread further into the mine.

In 1971 at a mine known as H.C.J. Contractors a fire-damp explosion resulted in the loss of 28 lives. The mine fan had stopped because of a power failure. The restarting of the fan led to the movement of a body of inflammable gas which had gathered while the fan was stopped. An explosion took place shortly afterwards. It seems probable an accumulation of methane was ignited by a naked flame. The mine had not been declared a fiery mine as fire-damp had not previously been detected or reported. The explosion was localized and did not spread. The workings had been stone-dusted to some extent.

3.2. **Transvaal and Orange Free State—**

Until 1945 in the Transvaal and the Orange Free State the coal-dust explosion prevention regulations, as amended from time to time, were applied to all mines which had been declared fiery. Between 1913

and 1945 five explosions in which six or more lives were lost, occurred in the Transvaal and the Orange Free State. All were methane explosions in which coal-dust apparently played either no part at all or only a minor part. Both fiery and non-fiery mines were included in these explosions.

The more significant explosions are commented on briefly:

In 1915, at an unspecified mine, a mine overseer opened his safetylamp in an unsuspected accumulation of fire-damp. An explosion resulted and seven persons were killed.

In 1934 at Schoongezicht Colliery in the Transvaal African workmen entered the working faces of a section before the miner had arrived to carry out his initial inspection. Evidence indicated a naked flame caused a methane explosion. Seven were killed. The mine had not been declared a fiery mine and was not stone-dusted. The explosion, however, was localized. After this incident the mine was declared fiery and stone-dusting was insisted upon.

In 1935 at the New Marsfield Colliery, which then consisted of a single outlet from the vertical shaft, a blown out shot in the presence of fire-damp caused an explosion which killed 78 men. The inquiry indicated the miner had blasted, knowing that fire-damp was present. It is probable that any stone-dusting which might have been carried out was inadequate, and that coal-dust might have affected the explosion.

In 1945 at the South African Coal Estates Navigation Colliery a blown out shot ignited fire-damp which had accumulated in a stall because of inadequate ventilation. The explosion caused the death of 14 men. The workings were either wet or had been stone-dusted and the explosion did not spread.

In 1944 the manager of Douglas Colliery, a non-fiery mine, appealed against an instruction by the Inspector of Mines to apply stone-dust. A commission was appointed to hear the appeal and investigate the circumstances. The appeal succeeded largely on the ground that insufficient coal-dust to propagate an explosion could be raised from the roadway surfaces. The figure taken as being the least quantity of coal-dust which would have to be raised into the air as a cloud to enable a coal-dust explosion to develop was 0.35 ozs. per cubic foot; careful sampling of the mine showed that this figure was not approached in practice.

In the majority of mines in the Transvaal and the Orange Free State similar conditions prevailed. The mine managers applied for the

instruction regarding stone-dusting to be withdrawn and, on the basis of the results of the Douglas appeal and an investigation of each individual case, the requests were granted.

Between 1945 and 1972, six explosions in which six or more lives were lost took place in the Transvaal and the Orange Free State coal fields. These explosions were all methane explosions confined to the area where gas was present. Although coal-dust must have been ignited no evidence could be found to suggest that flame had extended for a distance greater than that which could be attributed to methane alone.

A brief account of these explosions is given

below: ***Transvaal—***

In 1956 in a section of Schoongezicht Colliery when two auxiliary fans were restarted an accumulation of fire-damp in a dead-end stall was driven back over obsolete and damaged switch gear. An explosion was set off by an electric spark. 12 men were killed. The mine had not been stone-dusted.

In 1957 at Springfield Colliery an electrical fault interrupted the power supply. As a result, the auxiliary fans in the section stopped, and fire-damp gathered at the working faces. When power was restored an electrical coal cutter was started before a test for fire-damp had been carried out. The housing of the coal cutter switch was defective and not flame-proof. A spark at the switch set off an explosion which killed eight men. The mine had not been stone-dusted.

Orange Free State—

In 1949 at Cornelia Colliery an auxiliary fan was stopped over a week-end. On the following Monday morning African workmen illegally entered the working places before the miner-in-charge had arrived to make his pre-shift examination. An explosion took place and six persons were killed. The cause of the ignition could not be discovered. There had been no stone-dusting.

In 1951 at Cornelia Colliery a blown out shot in the presence of fire-damp caused an explosion which killed 26 persons. The miner-incharge allowed unauthorized persons to carry out blasting operations. No test was made for fire-damp before blasting took place. There was no stone-dusting.

In 1961 at Coalbrook Colliery eight persons were killed by a methane explosion caused by the unauthorized use of flame cutting equipment in an incline shaft.

4. Although this history of explosions in South African coal-mines provided some reassurance as to the validity of the decision arising out of the Douglas appeal, the question why coal-dust had apparently played no significant part in any of the explosions remained largely unanswered. It was known that the coal-dust, in each case, was sufficiently high in volatile content to be explosive. The reason why coal-dust explosions did not develop can possibly be ascribed to one or more of the following circumstances—the quenching effect of the naturally high ash content of the coal; the possibility that sufficient coal-dust was not present on the roadway surfaces; or if sufficient coal-dust was present, the force of the methane explosion in each case was either not sufficiently powerful to raise a dense enough cloud or expended itself in the pattern of inter-connecting high and wide bords before a cloud could be raised. The use of water at the working face to allay dust for health reasons and good housekeeping procedures at the mines could well have had a bearing on the amount and dispersability of coal-dust at or near the point of origin of the ignition.

Prior to 1961 the Department of Mines kept itself informed of progress in coal-dust explosions research and preventive practice in other coal-mining countries. In the light of this knowledge it considered whether it was justified in relaxing the requirement that stone-dusting should take place. The Coal Mining Research Organization was created in 1961. In March of that year a meeting of experts on mine disasters was held at the International Labour Office in Geneva at which the Department was represented. The discussions at that meeting revolved mainly round the means of preventing and arresting coal-dust explosions. On the basis of the work in that field by Professor Cybulski and others the firm opinion was reached that precautions against coal-dust explosions should always be taken in all coal-mines where the ratio of volatiles to total combustibles exceeded 14 *per cent.* **In South Africa the Coal Mining Research Controlling Council instructed that the investigation of the coal-dust explosion hazard should receive attention as a major research project.**

In the ensuing years determined efforts were made to ascertain if immunity from coal-dust explosions in the Transvaal and the Orange Free State Collieries could be secured without having to resort to stone-dusting. Intensive laboratory tests in South Africa and gallery tests in Germany were carried out by the Fuel Research Institute under the aegis of the Coal Mining Research Controlling Council but the results of the work did not, however, provide the necessary assurance and early in June, 1972, it was decided that more positive steps to

remove the uncertainty would have to be taken. A few days later the explosion at Wankie showed that a history of immunity from coal-dust explosions had little value. This disaster expedited the decision that existing exemptions from stone-dusting should be withdrawn. Industry was receptive to the decision. The Department and the Industry, through the medium of a liaison committee are at present preparing a code of practice for controlling dust production and, also, a programme for the introduction of stone-dusting on a comprehensive scale.

APPENDIX 'D'

Methane Readings No. 2 Colliery

May 1967.	Bisa West/No. 5 Road 4%
Jan. 1968.	Accumulation on the North Barrier
Feb. 1968.	Railway Main—all drives Bisa West—North Barrier Subsided area—East Panel/North Barrier over 5% intersection with No. 1 Cross-cut. Over 2% intersection with No. 2 Cross-cut.
Nov. 1968.	HE1 (Making Lot) Railway (small traces) 12 Panel 2 East (3% through test pipe—intend to bleed).
Dec. 1968.	HEI (still making lot) 12 Panel 2 E (2,8% at Regulator).
Jan. 1969.	HE I (Continually at one stage 2,5%). NMI No. 6 Cross-cut J Road 2,8%.
Sept. 1969.	Considerable amount detected in HEA and HEB when there is a fan failure.
Oct. 1969.	Heavy concentrations Railway North.
June 1970.	Railway North Main (traces when power failed) HE3 (up to 5%).
July 1970.	HE3 (Traces) HE2 (11% increasing to 4%-5% with fans off for six hours).
Aug. 1970.	HE2 (same as last month).

Oct. 1970.	HE3 (up to 5% when fans off for 15 minutes). Railway North (1% East Barrier). HE2 Ignition separate report.
Nov. 1970.	HE3 (up to 5%) Railway North (up to 2%) fans on stop + 15 minutes. HE2 (Up to 1%).
Dec. 1970.	HE3 same as November.
Jan. 1971.	HE3 and Railway North (up to 5%) fans on stop + 15 minutes.
Feb. 1971.	Same as January.
March 1971.	Railway North (up to 5%) fans on stop + 15 minutes.
April 1971.	Same as March.
May 1971.1 June 1971.f	No comments on gas in report.
July 1971.	SW ex G South ex Railway Main G West North (5% bubbling from floor).
Aug. 1971.1 Mar. 1972. f	No comments on gas in report.
April 1972.	Matura Main (small amounts up to 1%) fans on stop + 15 minutes.
May 1972.	Matura Main (methane still being detected when Auxiliary fans are on stop for + 15 minutes).

The miners daily report for the **Matura section** on **24th** May, 1972 reads:

"Belt Road 5%, F Road 3%, E Road 3%".

"Belt Road, F, E Roads no fan piping".

"We **must** get more fan piping in this section".

APPENDIX `E'

Examination and making safe by miner—Coal mines

8.9 In every coal mine-

8.9.1 every working place which has remained idle for more than six hours, or which has remained idle for such lesser interval than six hours

as the Inspector of Mines may direct, and every working place in which blasting has taken place, shall be examined and made safe by the certificated ganger or miner in charge of the section in which such working place is located before any work is resumed in any such working place;

8.9.2 notwithstanding the provisions of regulation 8.1.1 and except as is provided for in regulation 8.9.3.1, no person other than the holder of an appropriate blasting certificate shall enter, and no ganger or miner shall cause or permit any other person to enter, any travelling way or working place in a section until such travelling way or working place to which any person is required to have access has been examined by the ganger or miner in charge of the section and found to be satisfactorily ventilated and in safe condition;

8.9.3.1 a scheduled person who is the holder of a gas-testing certificate issued by an institution recognised by the Government Mining Engineer for the purposes of regulation 28.40.7.3 may enter with his gang and work in the section inbye of the waiting place required in accordance with regulation 2.10.6 when a certificated ganger or miner is not present, provided that—

(a) such work shall have been specified and authorised by the manager or mine overseer but shall not include coal getting,

(b) the ganger or miner in charge shall, at the end of the preceding shift, have examined and if necessary made safe every place to which such person and his gang are required to have access,

(c) such work shall not continue for more than four hours in the absence from the section of a certificated ganger or miner, and

(d) the person in charge of the work shall cease work immediately and withdraw all persons should the ventilating air current diminish noticeably or the place where the work is being carried out become unsafe;

8.9.3.2 when making the foregoing examination no light or lamp other than a light or lamp approved by the Government Mining Engineer shall be used;

8.9.4 at the commencement of his shift the ganger or miner—

(a) shall examine every working place in his section for inflammable gas with an approved flame safety lamp,

(b) shall place his initials and the date of the examination in chalk or crayon in a conspicuous place other than on the coal face itself, in every working place immediately after he has examined it,

(c) shall immediately fence off or set up a barrier at the entrance to any place which he finds to be in an unsafe condition and which he cannot there and then make safe and, until he shall have personally made such place safe, he shall allow no person to enter therein except such persons as may be necessary to assist him in making such place safe,

(d) shall inform the mine overseer or shift boss by the quickest means available if noxious or inflammable gas is found during his examination, and

(e) shall immediately after the inspection of the section record in duplicate on a form approved by the Inspector of Mines in a book provided for the purpose by the manager a full and accurate report specifying whether or not and where noxious or inflammable gas, defects in roof and sidewalls and other sources of danger were found or observed. The ganger or miner in charge shall sign the report and shall send the original thereof, immediately it has been made, to the surface for transmission to the manager's office. This report shall be countersigned by the manager on receipt and shall be retained by him for at least three months;

8.9.5 the ganger or miner carrying out the examination and making safe required in regulation 8.9.4 (a) and (b)—

(a) shall take all reasonable measures to prevent persons not required to assist him from entering any such working place until he has examined and made safe and until he has given them definite instructions to enter,

(b) shall, except as is provided for in regulation 8.9.3 take all reasonable precautions for the safety of persons present to his knowledge in his section and for the safety of his gang and such precautions shall continue as long as he allows any such person to remain in his section or until he is relieved of responsibility therefor by another certificated ganger or miner. Such relieving ganger or miner shall by means of a token to be handed to the ganger or miner relieved, or by such other

means as the Government Mining Engineer may approve, signify that he has assumed responsibility for the safety of the section, and

(c) shall not be a contractor for the getting of minerals in the mine;

Inspection during the shift

8.9.6 the ganger or miner in charge shall, in the course of his shift, make at least three inspections at intervals not exceeding three hours of every working place in his section;

8.9.7 where coal pillars are being extracted, the ganger or miner **shall not have charge of more than 12 working places or such lesser number of working places as the Inspector of Mines may determine for the particular section of the mine and the said inspections shall include all accessible portions of the goaf edge of each working place;**

8.9.8 where a section which is giving off inflammable gas freely is being opened out the ganger or miner shall not have charge of more than six working places and he shall make inspections at intervals not exceeding one hour;

Tests for inflammable gas

8.9.9 in the course of every inspection made in terms of regulation 8.9.6 the ganger or miner in charge shall **test for inflammable gas with an approved flame safety lamp and if inflammable gas is detected in quantity sufficient to show a distinct cap on the reduced flame of the safety lamp to necessitate the withdrawal of persons in terms of regulation 10.6.5 he shall immediately report its presence to the manager, mine overseer or shift boss by message sent in writing;**

8.9.10 in the course of each shift a test for inflammable gas similar to the test required in terms of regulation 8.9.9 shall be made by the manager or by a competent person other than the ganger or miner, appointed by the manager, who shall be the holder of a permanent blasting certificate appropriate to the class of mine to which the mine belongs, of every part of every miner's section in which workmen work or travel or may be required to work or travel during that shift. A report on every such test shall be recorded at the end of that shift, by the person making the test, on a form approved by the Inspector of

Mines in a book provided for the purpose by the manager. Such report shall be signed by the person making it and it shall be examined and countersigned by the manager or mine overseer within 24 hours.

APPENDIX

Coal dust explosion prevention

10.24 Except in so far as exemption may have been granted by the Inspector of Mines to such degree and subject to such conditions as he may prescribe in writing, the following provisions shall apply at every coal mine:—

10.24.1 No plant for sorting, screening or crushing coal shall be erected in the workings, and no such plant shall be erected on the surface within a distance of 75 metres from any downcast shaft or other opening where ventilating air enters the workings.

10.24.2 Arrangements shall be provided and used at every plant for sorting, screening or crushing coal to ensure that as little coal dust as practicable enters the workings.

10.24.3 Arrangements shall be provided and used in the workings to prevent, suppress, collect and remove, so far as practicable, the fine coal and coal dust created by mining operations.

10.24.4 In all accessible workings every road shall be treated with incombustible dust to ensure at all times that the dust that can be raised into the air from the floor, roof or sides of the road shall contain not less incombustible matter than is determined in accordance with the following table:—

Percentage by mass of volatile matter content, calculated on an ash-free dry basis, of the coal being mined.	Minimum percentage by mass of incombustible matter content.
Over 14, not exceeding 20 .	50
Over 20, not exceeding 22 .	55
Over 22, not exceeding 25 .	60
Over 25, not exceeding 27 .	65
Over 27, not exceeding 30 .	68
Over 30, not exceeding 32 .	70
Over 32, not exceeding 35 .	72
Exceeding 35 .	75

For the purpose of this table the volatile matter content of any coal shall be that determined by analysis of a representative section of the seam or of a representative sample of run-of-mine coal from the seam taken within the preceding 12 months. Where no such determination has been made the percentage shall be deemed to exceed 35 per cent.

10.24.5 For the purpose of regulation 10.24.4, the manager shall ensure that a supply of incombustible dust equivalent to at least one week's requirements shall always be available in the workings for distribution and use and that such incombustible dust shall—

(a) contain not less than 95 per cent. by mass of incombustible matter,

(b) be of such fineness that, when dry, all will pass through a sieve of 600 micrometres aperture and at least 50 per cent. by mass through a sieve of 75 micrometres aperture,

(c) be a limestone dust that does not contain more than five per cent. by mass of free silica, or be some other dust that has been approved for the purpose by the Government Mining Engineer,

(d) be light in colour and of such character that, unless directly wetted by water, it does not cake and will readily disperse into the air when blown upon, and

(e) be tested at intervals not exceeding three months for its incombustible matter content and fineness.

10.24.6 For the purpose of determining the adequacy of the measures taken to comply with the requirements under regulation 10.24.3-

(a) samples sufficient in number and from appropriate locations so as to be representative of dust conditions shall be systematically collected at intervals not exceeding 30 days from the roads in each ventilating district or in each such section of the workings as the Inspector of Mines, after consultation with the manager, may require,

(b) (i) each sample shall be collected over a length of road not less than 50 metres in length,

(ii) the sample of the dust on the roof and sides shall be taken separately from the sample of the dust on the floor,

(iii) in the case of the dust on the roof and sides the sample shall be taken to a depth not exceeding six millimetres

and in the case of the dust on the floor to a depth not exceeding 25 millimetres,

(iv) every sample taken shall be representative of the whole surface of the roof and sides or the floor, as the case may be, of the length of road being sampled and shall be collected either by a method of strip sampling by which the dust is collected from a succession of transverse strips 10 centimetres wide and equally spaced not more than five metres apart, or by a method of spot sampling by which the dust for each particular sample is collected from one point for each one metre of that length of road,

(c) each sample shall be well mixed and a representative portion, after drying in the air if necessary, shall be passed through a sieve of 250 micrometres aperture and retained for analysis,

(d) analysis of the sample shall be carried out by the following method or by other methods approved by the Inspector of Mines: —

(i) The residue of a weighed quantity of dust, after that quantity of dust has been dried at a temperature not exceeding 140°C and the loss of mass attributable to moisture ascertained, shall be heated in an open vessel to a temperature not less than 480°C and not more than 520°C until the coal is completely burnt away. The incinerated residue shall be weighed.

(ii) The sum of masses of moisture and incinerated residue shall be reckoned as incombustible matter and be expressed as a percentage of the total mass of the dust.

In every case where unsatisfactory conditions are revealed in the places sampled, the return in terms of regulation 10.24.6 (e) shall reflect what remedial action has been taken.

(e) A record shall be kept of the date and place of each sampling and the results of the tests carried out under regulations 10.24.5 (e) and 10.24.6 (d). A return shall be sent each month to the Inspector of Mines clearly describing the places sampled and the results of the analysis obtained.

10.24.7 Roads along which coal is moved or transported shall be systematically cleared of any coal spillage and, before any area of the

mine is isolated by stoppings, the floor, roof and sides of all roads therein shall be systematically cleared of dust and freshly stonedusted.

10.24.8 Coal tubs shall be constructed and maintained so as to prevent coal dust escaping through the sides, ends or bottom.

(10.24.9 already quoted in the text, *see para. **4.17**, supra.)*

10.24.10 Once in every 24 hours a shift boss or an official of more senior rank shall report in writing, in a book provided for the purpose by the manager, on the measures taken to ensure compliance with regulations 10.243, 10.24.7 and 10.24.8 in the section of the workings under his charge.

10.24.11 For the purposes of this regulation—

"accessible workings" shall include all workings other than abandoned workings that have had all entrances effectively sealed by stoppings;

"incombustible matter" shall include moisture and combined carbon dioxide;

"road" shall include all roads of any description in the workings of the mine extending from the shafts, outlets, or inlets, to within 10 metres of the coal face.

App. "G'_

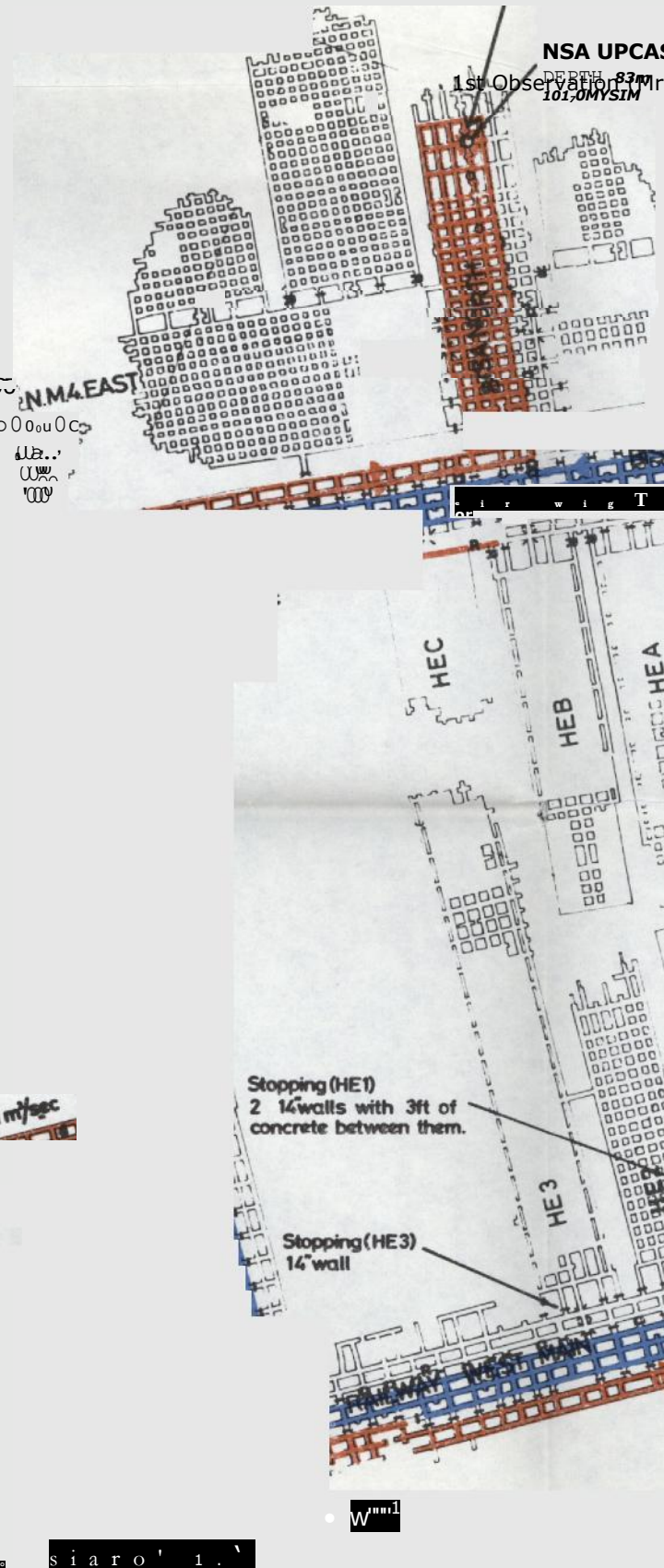
WANKIE COLLIERY CO. LTD. GENERAL PLAN OF PROPERTY

Boundary of Concession . .....
Area Mined cut to June 1972..
Area Reserved far i1D. 2 colliery
Area Reserved for No. 3 Colliery
Area Reserved for OpenLot Mining
Burnt Coal and Barren Areas

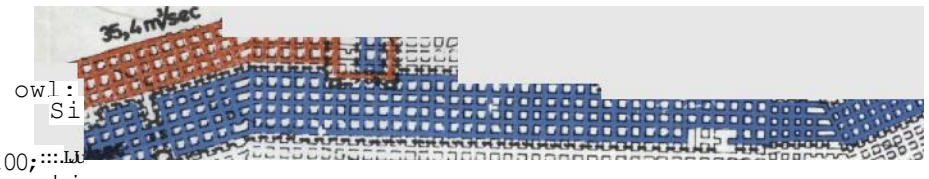
SALE jr I Mite
4,C0O' 2,c00' 0' 4,000' B,C00'

1

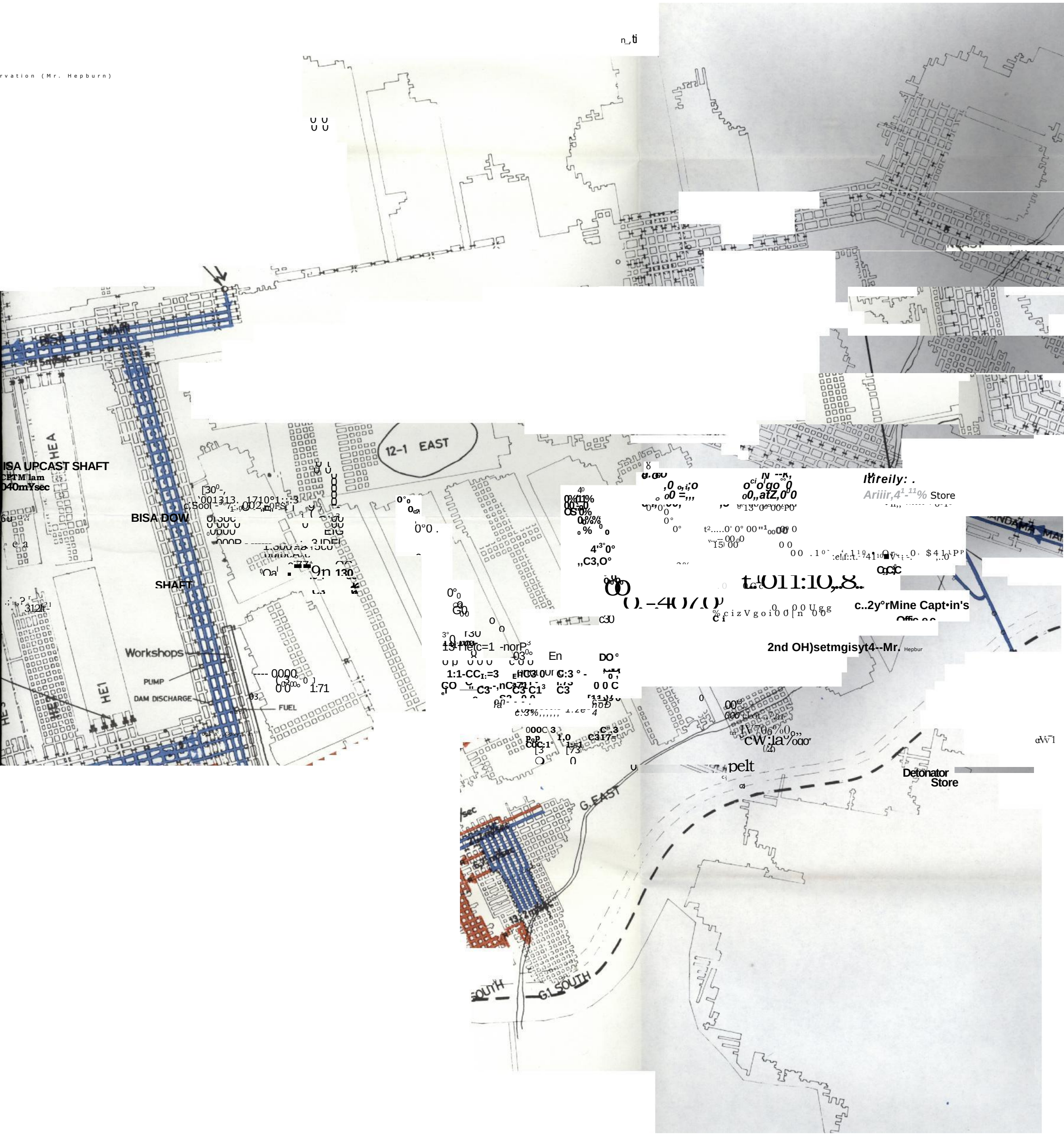
TO VICTORIA FALLS
DEKA R.
DEKA FAULT GROUP
½ MILE LIMIT
N 51,000
N 50,00
No Coal
CLAY PITS
AFRICAN VILLAGE
Chambuma R.
Bisa Main
Bisa West
Shaft
Kamandama Main
NDUMEBISA
COLLIERY RAILWAY
No. 2 COLLIERY WORKINGS
No. 1 COLLIERY WORKINGS
OPENCAST AREA
OPENCAST AREA
Burnt and Barren Area (No Coal)
RHODESIA RAILWAYS
HOTEL
MINE OFFICES
HOSPITAL
WANKIE TOWNSHIP
OLD aS STATIOn, PLANT AND POWER STATIO W •
NEW STATION
TO BJLAWAY0
AIRSTRIP
OPTION AREA
No. 3 COLLIERY
PLANT
Main East
14 East
45 West
Burnt Coal
FUTURE
FUTURE YINING AREA
MINING
AREA
Burnt and Barren Area (No Coal)
Burnt and Barren Area (No Coal)
PROPOSE) RAILWAY E TENTION
SHAFTS
Propose Cottiery
Na.4
S. G. 497


NSA UPCAST SHAFT
1st Observation (Mr. Hepburn)
DEPTH 83m
101,0MYSIM
BISA DOW
AST
N.M4.EAST
HEC
HEB
HEA
HE1
HE3
Stopping (HE1)
2 14"walls with 3ft of concrete between them.
Workshops
PUMP
DAM DISCHARGE
Stopping (HE3)
14" wall
8,6m/sec
20,1 m/sec

OPENCAST RESERVE



rvation (Mr. Hepburn)



Explosives
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Store

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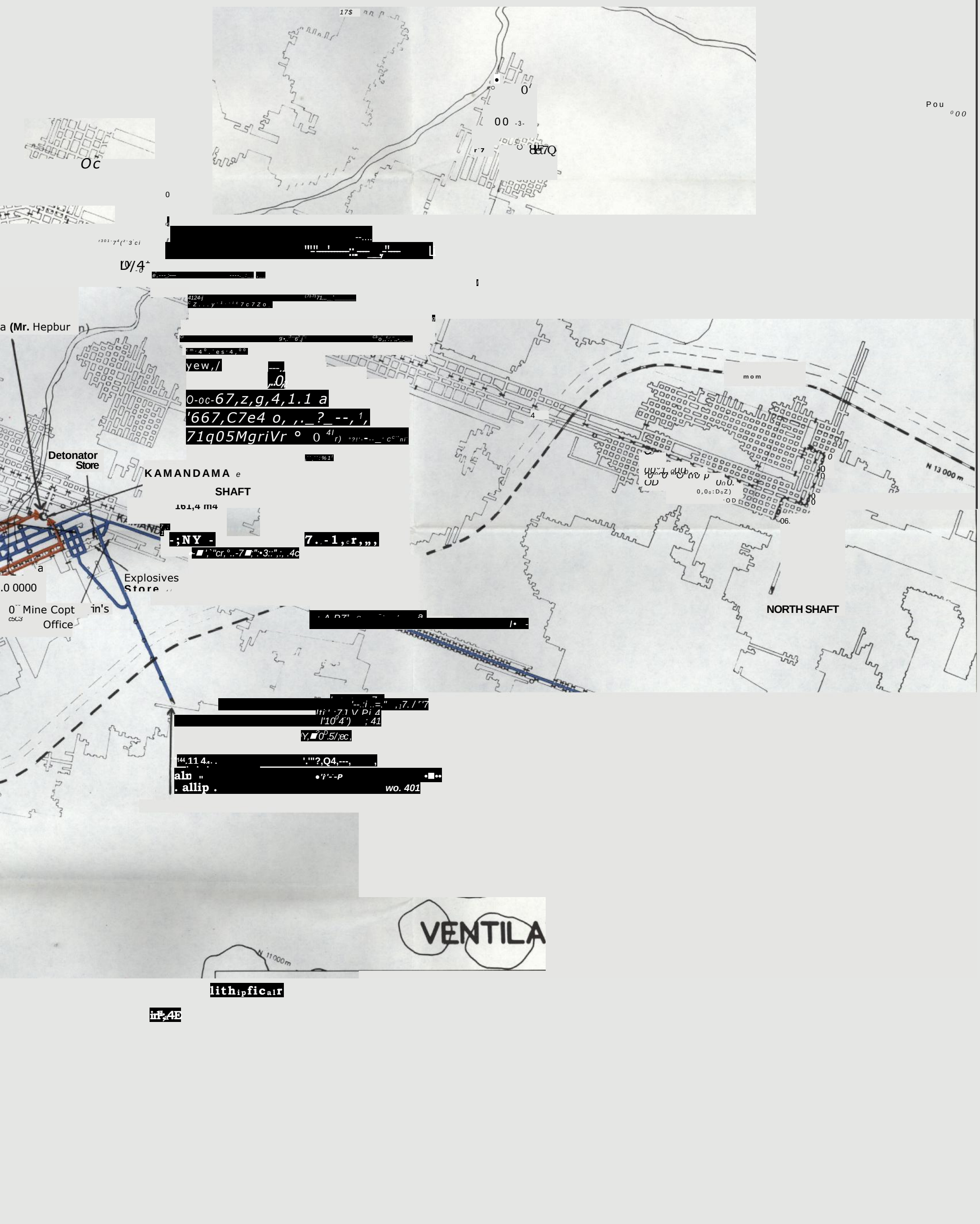
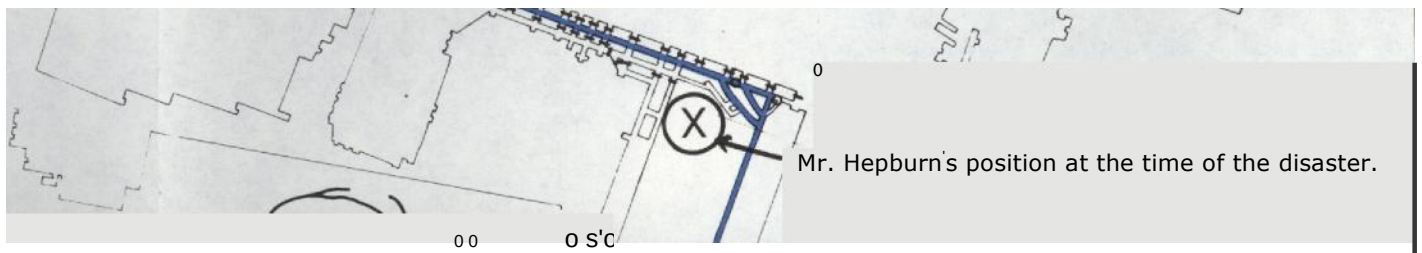
3rd Observi

OPENCAST RESERVE

OPENCAST RESERVE


Detonator Store
KAMANDAMA
SHAFT
Explosives Store
Office
NORTH SHAFT
N 13 000 m
VENTILA

KAMANDAMA SHAFT
C
DEPTH 66 m
72,6mYsec



3rd Observation (Mr. Hepburn)

CENTRAL DC SHAFT
DEPTH 26 m
27,4 mYsist

TI9N SYSTEM

WANKIE COLLIERY CO Ltd.

PLAN OF No. 2. COLLIERY

SHOWING **VENTILATION SYSTEM**

SCALE 110 000

LEGEND

AIR BLAST STOPPINGS.__x
AIR CROSSINGS AUXILIARY FANS_ _ _ DOORS - _ _ _
REGULATORS
SHEETS _
STOPPINGS

INTAKE AIR ----------
RETURN AIR
KAMANDAMA UPCAST FAN 3 C W.G.
BISA UPCAST FAN 1"2 W. G.
QUANTITY OF AIR CIRCULATING WORKING
TOTAL QUANTITY OF AIR
SUBSIDENCE _

181,4 m'/sec
101,0 m'/sec
SECTIONS 184, 9 mYsec
—271, 5m'/sec

DRAWN BY D J.ALMOND FROM INFORMATION SUPPLIED BY WANKIE COLLIERY CQ Ltd.

SATE **17/7/1972**

Plan No. LBW 5