DAY 11

NOVEMBER 23, 1995

WESTRAY MINE

PUBLIC INQUIRY

HEARD BEFORE: The Honourable Justice K. Peter Richard, Commissioner

PLACE: Stellarton, Nova Scotia

COUNSEL:

Solicitor for the Commission: Mr. J. Merrick, Q.C., and Ms. Ena MacDonald, document coordinator

Solicitor for the Department of Justice Canada: Ms. Lynn Gillis

Solicitors for the Department of Justice Nova Scotia: Messrs. R. Endres, Q.C., J. Traves, and Wm. Wilson, Q.C.

Solicitor for the United Steelworkers of America and the Nova Scotia Federation of Labour: Mr. David Roberts

Solicitor for the Westray Families Group: Mr. B. Hebert

Representing the Town of Stellarton: Mr. Clarence Porter, Mayor and Mr. Phillip Rafuse, solicitor, and Mr. John Murphy, Town Councillor

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November 23, 1995 - 9:34 a.m.

COMMISSIONER   Good morning.

ALL Good morning.

DR. MALCOLM MCPHERSON, previously called and sworn, testified:

COMMISSIONER   Mr. Merrick?

MR. MERRICK   Thank you, Mr. Commissioner.

EXAMINATION BY MR. MERRICK

Dr. McPherson, I will try to keep you on schedule. The first thing I want to do is just revisit a point that Mr. Wilson was asking you about yesterday about the Kilborn Study. Can you turn to Exhibit 1 in that portion that he was referring to you yesterday, and it appears in approximately the middle of the book. It's at page 6.

A.   Yes.

Q.   Okay. It's just after that first section of plans in about the first part of the book. You go through a section of them and then we've got some numbered pages. I think it will be past the plans. All right, this is entitled "Page 6." At the top of the -- or at the bottom of the page is a Section 3.5, "Mine Ventilation." This volume is still a little hard to work with because it's got no master page system on it. Let me see if I can be of other assistance. Do you have it, Dr. McPherson?

A.   I have it, sir, yes.

Q. Okay. Accepting for the moment -- and we see there at the bottom of the page at 3.5 that apparently the objective of their exercise was to determine the air quantity that would be sufficient to dilute what they anticipated to be the methane emission rate.

A. Yes.

Q. And accepting the comments that you've already made that it isn't adequate to merely have as your objective the dilution of methane, but you should also have as your objective the mixing of methane, and then on the -- and accepting the premise as well that this ventilation description was based on a completely different layout of the mine than what we now see -- and the layout is just two pages further -- three pages further on, is a map that shows a layout that Kilborn was having in mind at the time they were talking about ventilation. And that is a layout that shows a number of different sections.

And whether or not each of their sections relates to what they were referring to as a production unit or not, we're not -- I won't get into in detail with you. Nor will I get into you -- in detail with you whether or not each of the sections would require more than two headings to be operating at any one time.

And I know your comments yesterday where you said that they had arrived at the conclusion that in order to dilute the methane all they needed was five cubic meters per second for each heading. And you've given the opinion that that would be inadequate.

Nevertheless, I assume from reading this that one could, by looking at their numbers, say that if they had 100 cubic meters per second of air volume going through, and if they only had five production units, and if each production unit was only two headings, that would give you 10 headings in total. You would then have 10 cubic meters per second per heading, and if you had that, would that be adequate to mix the air?

A. In that idealistic scenario, that would be so, Mr. Merrick. But I have never seen a mine that would develop in that almost cartoon fashion.

Q. All right. But 10 cubic meters per second per heading would be adequate to mix?

A. Would be adequate to mix to dilute the methane, yes.

Q. All right. Let me move on to another point. You said yesterday, and it was a comment that I just wanted to pick up on --

A. Mr. Merrick, can I just retract a moment?

Q. Yes.

A. I think we mixed our words there. We said would be adequate to mix and dilute. It would be adequate to dilute the gas. Again, one would have to look at the velocity heading by heading. It would be more than the 8.4 I said would be required. And according to those figures it would be sufficient to mix methane layers. But, again, this is looking at an idealistic scenario. I just wanted to clarify that.

Q. And I take it that your comments to me this morning still have to be taken in the context of your general comments about Kilborn that this page and a half of ventilation description is not really what you would consider a comprehensive or a detailed ventilation scheme?

A. It's the kind of calculation I would carry out literally on the back of an envelope, having discussed this very briefly, mine plan very briefly.

Q. Okay. Let me come to the second point that I just want an explanation on. You were talking about the stoppings that were put in in place in the Southwest district and we've heard evidence that the stoppings were not put in as soon as they had withdrawn from the old Southwest district, that there was a short period when they had the air circuits still going through there. You made a comment yesterday that if they had kept the ventilation circuit going, they would have had difficulty in establishing ventilation in Southwest 2. Do you recall that comment?

A. Yes, sir.

Q. Can you just explain what you meant by that?

A. The then abandoned area, Southwest 1, was subject to pressure causing crushing of the pillars, spalling of the rib sides. It was a prolific source of gas, had that the ventilation been maintained in order to continuously handle that source of gas, then it would have required a large amount of ventilation simply to ventilate those old Southwest workings. That's the first part of the answer.

The second part is that during that crushing of the pillars, the destruction of the pillars, it would obviously be impossible for anyone to go in there. It would therefore be impossible to maintain a ventilation circuit around the old Southwest 1 district. So one would still have a disrupted -- one would not have a circuit in there; it would simply be a mass of old workings.

Q. I understand. You were asked some questions about the cross-sectional dimensions of the road going up into the Southwest 2 district and the impact that the existence of a conveyor belt might have on that.

A. Yes.

Q. Now this was all in the context of the calculations that you used to determine whether the air velocity was sufficient to prevent layering.

A.   Yes.

Q.   Assuming for the moment that for portions of that roadway, at least, the conveyor system was up near the roof, what do you say as to the appropriateness of that kind of -- that for a location for a conveyor system?

A.   It is not unusual to see conveyors slung from the roof assisting it from resting on the floor. In the particular case of a mine which is producing coal that is gassy, and in this case we had a coal -- it was not only gassy, of a medium gas content, but was mining coal in the Southwest 2 district from an area of geological faulting. This would mean that the coal would have enhanced permeability, as we have already heard, and therefore that gas would come off readily.

One of the sources of gas that we have not spoken of to this time is the fact that the coal continues to make gas as it comes out of the mine on the conveyors, on the transportation system. Now in the Southwest 2-B Belt Road, that is fragmented coal releasing its methane readily. Because it is newly mined, mined only a few minutes before, because of the freshly exposed surfaces, because of the reduced size of the fragments, and the fragments from a continuous miner are quite small, so gas would be emitted from the coal along the conveyor route. In those particular circumstances, it would not seem

advisable to put the conveyor in the upper part of the entry where the velocities are reduced in any case.
Q. And where there is a potential of gas that's coming off there could be forming part of the layer?
A. Yes, sir.
Q. All right. Let me talk about your calculations and your opinion on whether there was in fact a layer coming up the Southwest 2-B Road. If it was in fact layering coming out of the old Southwest and it comes up the Southwest 2-B Road, I'll use the bigger diagram --
A. Uh huh.
Q. -- once it gets to the junction of Southwest 2-1 Road, this air circuit, the general body of air would be moving around to the left --
A. Yes.
Q. -- to go back out again. I assume that the general tendency of that layer would be more to go with the general body of air, would it, rather than going up into the heading?
A. We have two -- you recall we defined two causes of the layer to move, one was indeed as you have just suggested, the viscous drag of the air underneath; the other one was the buoyancy of the gas going up hill. So there would be a tendency of that gas, in addition to what you said, to continue to move up the slope into the

continuation of the Southwest 2-B Roadway.
Q. All right.
A. Whether or not it also still retained a concentration to move sideways into the -- on the right roadway, I forget the name of it here --
Q. Southwest 2-1.
A. -- Southwest 2-1, is a matter of conjecture.
Q. All right. Assuming for the moment that there was no layer coming up the Southwest 2-B Road, that for one reason or another it had in fact been mixed by the time it got to the junction point at least of Southwest 2-1 Road --
A. Yes.
Q. -- I take it that that doesn't change your opinion at all as to the possibility of a layer existing in Southwest 2-1 Road having been created by the make of gas during the mining operations?
A. That is correct. We do not need a layer coming up Southwest 2-B for there to be a layer in the headings. The layering in the headings would -- could have certainly been caused purely by the make of the gas in the headings.
However, there is one added comment I should make on that. If, indeed, there was no continuous layer of the Southwest 2-B roadway -- continuous -- then the first

scenario I gave yesterday, I gave two scenarios about the movement of the flame, the first scenario was the propagation of that flame and back along the fuse path of a layer, back into the Southwest 1 workings. If there had been no continuous layer along the Southwest 2-B roadway, obviously, that could not have happened. In that case the burning flames of methane obviously must have reached a concentration in the explosive range and of sufficient volume to cause the explosion somewhere before it reached the bottom of Southwest 2-B.
Q. All right. The one thing that we do know is that if the ignition occurred up in those headings, it obviously propagated --
A. Yes, sir.
Q. -- which means that there must have been a layer of methane up in there?
A. Yes.
Q. From wherever it came from, there had to be methane?
A. Yes.
Q. Yes. And we also know that there had to be enough methane and a layer of methane going far enough out and perhaps down the Southwest 2-B Road to have allowed the initial -- the ignition of the methane and the initial burning of the methane to propagate into an explosion and then have an explosion of sufficient force and shock wave

to pick up and go into a coal dust explosion?

A. Yes.

Q. Unless, of course, there was methane all over the mine, and that's not a question. So that whether or not there is a layer all the way up that heading doesn't change the fact that there was enough gas to start the explosion in that area, if that's where it ignited?

A. That is correct.

Q. And, indeed, in your answer to me just a minute ago I take it that it's conceivable that there may have been a layer coming up that Southwest 2-B Road even partway that may then have been ignited by the explosion?

A. Yes.

Q. Yeah. All right, I've got that. And I also assume that -- let me back up. You were asked about whether the stoppings that were placed in cutting off the old the Southwest district, whether Section 71(11) of the Act really applied to them or governed their construction because of the definition of where that section applied. Whether or not that section applies to those stoppings, I take it that it's clear in your evidence that whatever the legislation may mandate, prudent and safe mining practice did not justify those stoppings that were in fact constructed?

A. That is correct, sir.

Q. And that prudent and safe mining practice and any practice that is based on the criteria of safety for the miners would have required better stoppings as you described?
A. Yes.
Q. So safety required it, whether or not Section 71 required it?
A. Yes.
Q. You were asked if it would be possible for management to have considered those stoppings in the old Southwest district to be bleeder stoppings. You indicated that in your opinion they were not bleeder stoppings. Would any reasonable, prudent mine management have any basis to consider those bleeder stoppings?
A. I spoke on Monday, I believe, about the bleeder system of handling methane in old workings. And you may recall, Mr. Merrick, that the bleeder system involved a so-called bleeder return at the back of the far end of those old workings such that air flowing into the front of the old workings, picking up the methane, would then continue in that same general direction and be collected in the bleeder return and thereafter diverted into the main return. That is a through flow of controlled air through the old workings and the methane and air mixture then being collected at the bleeder return. That is the

situation in which a controlled amount of air is allowed to go through what you are calling "bleeder stoppings." I would refer to them as "regulators."

If you have no bleeder return on that far side, then you do not have a bleeder system. And in that case, leaving those stoppings on the front in a condition which will allow bleeding or breathing of air backwards and forwards is not advisable.

Q. And that would not be a decision that, in your opinion, a reasonably prudent mine management would consider an appropriate bleeder stopping system?

A. No.

Q. All right. You were asked about the adequacy of the stoppings as far as whether they were in good condition and whether they seemed to be doing the job. And you were referred to some inspection reports that are in Exhibit 37-A. If you can turn to that exhibit.

A. 37-A?

Q. 37-A. Sorry, these were the ventilation surveys. And in particular we know from those ventilation surveys that the suggestion is is that the stoppings that we're talking about now were not constructed until about April the 13th. And you were referred then to some indications in a couple of them about the stoppings being in good condition. Turn, if you will, to page 87. That's page 3

of the April 23rd, 1992, ventilation survey. And on page 87, under the "stoppings," I'm interested in the two in particular that are marked "C-1 inbye 3 Crosscut."
A. Yes.
Q. I assume that that has to be the first of those stoppings into the old Southwest district. That C-1 Road inbye -- wait a minute, down here, 3 Crosscut.
A. Yes.
Q. And we see there, "fair condition, plywood buckled." Bearing in mind that that stopping had been constructed just less than two weeks previously, what significance do we see that already plywood has buckled and it's only in fair condition?
A. It's an indication of the fact that the stress on the sides of the roadways, the pillars between the entries, is such as to cause convergence in those locations where the stoppings exist. Convergence will cause buckling. In properly constructed stoppings out of masonry, concrete, rigid material, it is often the practice to put so-called "squeeze pads" at the top of the stoppings made out of material intentionally designed to yield. Those are for that purpose. So this is an indication that the area is suffering from stress.
Q. So that even within two weeks of constructing them, they can only be described as fair condition and

buckling. And I would assume that if you note that the plywood is buckling, that is beginning to indicate that it's going to impair the efficiency of the stopping, whatever that efficiency had been?

A. Immediately cracks, fractures appear in it. Those will add to the fractures that inevitably exist anyway around the stopping to allow further leakage.

Q. All right. You were asked about whether -- if readings were taken of methane at the roof level, that if a ventilation survey indicated -- had no record of a reading at roof level then we might assume, therefore, that the gas reading at the roof level was okay.

Let me ask you this: would it not be the more prudent practice that if you actually take a reading at roof level that you will record the results of that reading, whatever it may be?

A. Yes, sir, indeed. Because methane is lighter than air, the first place one takes a reading when inspecting for methane is at roof level.

Q. And if it's okay, that is -- it is as important to record that it's okay or safe than it is to record if it isn't?

A. If you take a reading during a ventilation survey, it should be recorded.

Q. All right. The last topic I want to address with

you are the inspectors' reports about stone dusting.
A. Yes, yes.
Q. If you turn to Exhibit 73, you were directed -- that's a black ring binder, you were directed yesterday to some reports that we see under Tab 6 which started in January 22nd of 1992 --
A. Yes, I have them.
Q. -- indicating that the inspectorate was concerned about it. In light of the submission of those, I'm going to suggest you turn to Tab 8. These are additional documents that are in the possession of the Commission, and I'm going to take you through them very quickly because I know the time constraints we're under. Looking at Tab 8, the first document we see is an assessment report dated September the 4th, 1992.
A. Yes.
Q. Down under "Items Discussed," number 4, we see, "Manager's stone dusting and dust sampling programs?"
A. Yes.
Q. So that was an item discussed. Turn over to the next page, same date, same form. I'm sorry, 91. I'm going too fast here. Next page, it's the page 2 in that tab, actually. "Mr. Phillips said he will have a stone dusting plan in place by September 30th, 1991."
A. Yes, I see that.

Q. You see that?
A. Uh huh.
Q. All right. Let's flip over to the next page. This is a memorandum which, I would guess, reflects the items discussed and elaborates on what we just looked at. And if you turn over to page five of the tab, the big stamped "5" at the top, we see, "Stone dust plan, G. Phillips promised to have a plan in the Department's hands by the end of September, '91."
A. Yes.
Q. Let's keep going. If you can turn to page 8, sorry, 7, that's an assessment report dated September the 26th, '91.
A. Yes.
Q. September the 26th, that's right. And if you can turn over to page 9, we see there that on that day, at the top of the page, second entry, "Stone dust was very good on roof, sides and floor."
A. Yes.
Q. So that day they see that there is -- they record that. Turn over to the next page, page 10, October the 7th. This is a safety walkthrough, Item 7, "One shift in every set or section, men to be asked to work between shifts to stone dust dust section." Let me keep you going.

A. Yes.
Q. Page 12, safety walk report, I assume it's referring to the same incident because it's still dated October the 7th. "Rock dusting to be started and dusted daily between shifts."
A. Yes.
Q. So there is some recording that there is to be that done. Now let me take you to an assessment report dated October the 29th, '91. This is page 14. And if you turn over to the second page of it, middle of the page, "stone dust along No. 1 slope is fair. A new stone duster will arrive by November the 15th. The manager has agreed to have someone put stone dust in each area until the new duster arrives."
A. Yes.
Q. So this is October 29th. Let's keep going. The next one is dated December the 4th, '91. Page 16 of the tab, it should be, if anybody can find that. Turn over to the second page which is page 17.
A. Yes.
Q. So in December the inspectorate reports, "Stone dust was spread throughout the mine."
A. Yes.
Q. So there are some steps being taken, but it keeps coming back. Turn over to the next page. This is a

meeting held at Westray, December the 17th. If you turn over to page 19, the second page of that meeting, we see the item stone dust, "G. Phillips said they had two machines to spread stone dust." Second paragraph down: "Following some discussion, C. White was assured that the stone dust scheme would be filed by the end of January '92."
A. Yes.
Q. Apparently no stone dust plan other than getting men to work overtime has yet surfaced. We come to the next page, page 21, which is -- I'm sorry, we then go back to tab 6, which are the documents submitted yesterday. I'm trying to go in sequence here.
A. Yes.
Q. And we see there -- I'm trying to find any reference there to where there was stone dusting.
A. At the bottom of the page.
Q. Oh, yes, you're right. "Stone dust needs to be spread on a more regular basis, and Mr. Parry agreed to see to this." All right, then we go to the next document under that tab 6, a document you looked at yesterday. This is February the 13th now. "Rock dust need in different area of the mine. Housekeeping, et cetera." Okay. Now turn back to tab 8 and we'll pick up the sequence at page 21. We're still February, this time

February the 19th.

A. Yes.

Q. And that's an inspection report in which stone dusting was not mentioned. We assume that there is nothing that caused the inspector to be concerned about stone dusting on that occasion. Turn to page 22 under that same tab. This is minutes of a meeting, February 26th, '92, page 23, the second page of that. "G. Phillips reported that rock dusting would be on-going with sampling procedures and stations in place in the immediate future. Samples would be taken in conjunction..." et cetera. "A. MacLean requested that these systems be in place by the end of March with written procedure and system submitted to the Department of Labour." Let me keep moving here. Then page 26 under that same tab, we now come to March the 2nd, meeting held at Westray, "Item 5, stone dust, two machines are working good and dust samples will be in place by March 15th." And then we go back to tab 6 to pick up the sequence and the last document that's under that tab is on that last page where it says: "Mr. Parry agrees to look after the items of concern. Also stated that a plan for stone dusting is being put in place."

Now that merely completes to the extent that we have documentation, the full recording dealing with stone dusting. Does that change your opinion at all as to the amount of vigour that was being exercised by the inspectorate officials in bringing that stone dusting item under control so that, as you said it yesterday, it would no longer be a problem?

A. I would seem to reinforce it, Mr. Merrick, what we have looked at under your guidance going back to September 30th, 1991 is the matter of stone dusting being brought up time after time after time, promises having been made by the mine management to do something about it, including the putting in place of a stone dusting plan. Despite all of those references to stone dusting and despite all of those promises, nothing seems to have been done. The impression one gets is that the management were essentially listening to the admonitions of the inspectorate and ignoring them.

MR. MERRICK Those are all the questions I have for you on re-direct.

EXAMINATION BY COMMISSIONER

Q. Dr. McPherson, before you depart here, I have one question that I wish to place before you. In a report in Ontario on mine safety, the Chairman in his report made the following statement, and I quote to you:

"We have found that a strong management commitment to safe production, that is, an organization requirement that defined safety standards be met, is the dominant common characteristic exhibited by the companies which demonstrates superior performances.

We have discovered further that it is the chief executive officer who sets the tone and insures that safety is given the priority which it deserves. He establishes the policy, defines responsibilities, and allocates the resources necessary to bring about a safe working environment."

Now given that quotation, Doctor, I ask you a two-part question: One, do you generally agree with that statement; and, secondly, if you do, is there any evidence that such an attitude or approach was present at Westray?

A. The answer to your first question, Mr. Commissioner, is I wholeheartedly agree. One often hears at mining conferences and talking to mine officials and mining company owners and operators the saying that "A safe mine is a profitable mine." And that certainly seems to be borne out by the records of successful and unsuccessful mines around the world.

If I may elaborate just one moment on this, this is not at all a matter that should be wondered at. A mine is successful like any other industrial or commercial enterprise dependent primarily upon the people. In mining we have other issues, of course, the geology, the difficulties, the hazards of mining, but, primarily, the success of the mine in any given geological environment depends on the people that are involved in it and the people are the management as well as the work force. It is very important to, if a mine is to be successful, to have a high morale, to have good labour relations, to have a happy work force.

All of these things will suffer if the miners are required to work in conditions that are either uncomfortable -- mining underground is never exactly comfortable, but in the context of mining, and that they also feel that they are working in safe conditions. If they have questions, if they are uncomfortable, if they are conscious of safety problems, then the morale will suffer. The relationships between management and the work force will suffer and, in those cases, this will have a direct effect on the productivity, the success of the mine. So my answer to that first question is wholeheartedly, yes. Let me repeat, a safe mine is a profitable mine.

With respect to your second question, that psychological environment of creating that good morale, engaging in matters that will lead to good labour relations and a happy work force, those are matters that clearly depend on the philosophy adopted by the management. The putting into place of procedures for training, the putting into place of systems which result in safe and reasonably comfortable conditions. Those are matters that are decided by management and the position of a chief executive layered on top of the immediate level of mine management, again that philosophy must come from the very top.

I have spoken of the conflict which seems to have been apparent at Westray, a conflict between the production of coal at the expense of safety. The philosophy that developed such a situation at Westray, I would suggest, would be one that has permeated that company from the top level management to the mine level of management.

COMMISSIONER Thank you very much, Dr. McPherson. You may step down and drive safety. Staff Sergeant MacDonald may give you immunity on your way to the airport.

A. I hope.

WITNESS WITHDRAWS

FREDERICK REGINALD BROOKES, sworn, testified as follows:

CLERK Could you please state your name and spell it for the record?

A. My name is Frederick Reginald Brookes. F-R-E-D-E-R-I-C-K. R-E-G-I-N-A-L-D. B-R-double-O-K-E-S.

DIRECT EXAMINATION BY MR. MERRICK

MR. MERRICK Mr. Brookes, have a seat. You presently reside where?
A. I live in Cheltenham in England.
Q. You're presently retired?
A. Yes.
Q. At the time of the employment, your retention by the Westray Inquiry, for how long had you been retired?
A. I had been retired for five years.
Q. Now where had you been employed at the time of your retirement, your previous employment?
A. I've been employed at the Safety in Mines Research Establishment which was also known as the Health and Safety Executive.
Q. All right. Let me ask you a few questions about that. I'd like to know a little bit more about that establishment and generally how it developed and the work that it does. Can you give me a brief history and a lead-up?
A. Yes, the original work on the coal dust explosion and the mechanism started early this century at one of the -- actually one of the mines, the first gallery was set up. But then that wasn't a suitable location, obviously. So it was done in the northwest of England in Cumberland where an establishment was set up and the

director of that establishment was the professor of fuel technology at Sheffield University and he combined the two jobs.

But then engineering and the electrical work started in Sheffield and part of the university buildings were leased for that purpose. But this was not very convenient for the large scale dust explosions. So a suitable site was found at Buxton, which was about 30 miles from Sheffield, a site on the moors and plenty of space to carry out these types of experiments. So this started in the late '20s and carried on.

It was partly subsidized by the government and partially by the coal owners. But after the war in 1947, the mines in Britain were nationalized and came under the jurisdiction of the National Coal Board, which was a quasi sort of a government set-up. The people at the laboratory which had developed on that site at Buxton became part of the civil service, and it was renamed the Safety in Mines Research Establishment.

And then in the early 50s, the work expanded, and about the time when I joined them, they were recruiting quite a lot of people and starting up new sections to cover various aspects of mine safety. They had been doing work on coal dust explosions for a long time. They had been testing explosives, testing electrical equipment for safety for flameproof equipment that was used in mines.

But then they started sections on the investigation of mine fires, on frictional ignitions in mines, on gas explosions and that type of thing.

Q. So that each particular problem area or anything that seemed to be a particular problem area, a section would be set up to be able to study it, research it, develop recommendations.

A. Yes, that's correct.

Q. Something that we in Canada perhaps don't appreciate is the extent to which this was -- that there was a legitimate basis for the effort that went into this kind of research in England. We have very few coal mines in our country. I assume that -- I understand that in England there were a number of coal mines.

A. Yes, I think speaking roughly, I would think in the 1950s there probably would be around about a thousand mines.

Q. A thousand mines?

A. Yes, something like that.

Q. And I assume that there were a number of incidents in those mines.

A. Yes, they occurred from time to time, yes.

Q. All right. So this Safety in Mines Research

Establishment, I assume was of considerable size with its various sections. How many employees would have been employed at its peak?
A. Oh, the Buxton site, which was the explosion site, there would be about 120, and there was more than that in the Sheffield laboratory, where by now they were doing the engineering and the electrical side.
Q. And you're talking about explosions. I understand that you would actually construct a gallery or a mine layout or a mine heading or roadway.
A. Yes. In the early days, the coal dust explosions were carried out in steel tubes only about four feet diameter. But plans were made to build a sort of mine-sized roadway, and this would be open around about 1960, something around about that time. This was a gallery which was about 400 yards long and about 60 square feet in cross section and of arch shape, so that it simulated a mine roadway. And this was used for coal dust explosions from that time on.
Also there was an underground roadway about 700 feet long built under a hill on the site, and that was used for fire research.
Q. All right, and this Safety in Mines Research Establishment, I understand, really acquired quite a world reputation for its research.

A. Yes, indeed. Every second year, there was an international conference on mine safety and the establishment at Buxton and Sheffield was very well represented at those meetings. And typical of the sort of work that was done, Dr. McPherson referred to the layering number developed by Baake & Leach. Baake & Leach were scientists who were employed at the Sheffield laboratory, and some of that work on the methane roof layering was done in the underground tunnel at Buxton.
Q. I see. So that's where the layering index number was developed?
A. Yes.
Q. And I take it there were other things that we now take for granted in the mining industry, safety equipment and such that was developed there.
A. Yes, the methanometer that is widely used, the hand-held spotter type methanometer, which I believe was used at Westray, that was an invention of someone at our Sheffield laboratory. A detecting device known as a pelister was developed at Sheffield. And the other two, the methanometer that was in use was a very bulky piece of equipment which was connected to a miner's electric lamp battery. Of course, it was very heavy to carry about, but this development allowed the hand-held methanometer with -- requiring far less calibration as

well -- to be used.
Q. I understand as well that this Establishment carried out the certification testing for equipment that would be used underground.
A. Yes, any heavy duty equipment such as switch gear or, indeed, any other equipment on the machinery, et cetera. The drawing, original drawings had to be submitted and checked at Buxton and then the prototype model was sent to the laboratories and tested there before it was certificated to be allowed to be used in mines.
Q. Now I understand from your resume that in Exhibit 53 under tab 1 that you commenced your employment with the Safety in Mines Research Establishment in 1951. Is that correct?
A. Yes, that's correct.
Q. And would that have been immediately following your university training?
A. Yes.
Q. What was your university training?
A. I took a degree in physics and mathematics.
Q. And you then commenced employment in the coal dust explosion section. That would have been one of the sections that were set up as you described to look into coal dust explosions?

A. Yes.

Q. And I take that, or I understand that your work in that section for those years would have been primarily involved in investigating dust suppression methods.

A. Yes. Because of the work involved in carrying out stone dusting in mines in which you've got to have, in Nova Scotia, 65 percent incombustible dust mixed with the coal dust, so you've got to add a lot of stone dust to the dust already in the mine to make it safe and inert. So we were looking at alternative methods which would perhaps be easier to apply, and one of the things we looked at was known as "the salt crust process" of roadway dusting inhibition. It was to cover the whole of the roadway, floor, roof and sides, with a layer of rock salt applied wet so that you got a coating of rock salt over the whole surface of the mine. And the idea behind it was as the dust settled out from the mining operations, that the salt would dry out and crystallize and bind the dust into that base. And then you'd go along and spray water on it, dissolve some of the upper surface, and more dust would settle and the drying process would occur again. In this way, you built up a layer of rock salt and coal dust which would render the mine safe and keep the dust bound down.

Q. That system, I take it, we know or we understand that it isn't being used. I take it there were problems with that.

A. Yes, one problem was that the corrosive effect of salt which the mining community were not keen to use. We didn't think at the time that it would be a great problem because of the way we were doing it, but that was one objection, I think, that the mining industry had.

Q. Let me take you to --

A. Sorry, the other point was that the salt, sodium chloride, won't dry out if the humidity, the relative humidity of the air is above 75 percent. So that kind of limited its application in certain places.

Q. Let me take you to the work that you then did with the explosives research section. I understand that your work there was, as you say in your resume, to basically examine how a methane explosion would start, develop methods of studying the shock waves produced by such explosions, and look for methods to be able to record and analyze it, such as very high speed photography.

A. Yes. The detonation processes in mining explosives is very fast. The detonation wave travels down the stick of explosive at about 2,500 meters per second. So if you go to study this phenomenon, you don't have much time to film it. And for this reason, we applied the use of a camera that had been developed for work in the atomic weapons industry which would give us 34 frames at roughly one microsecond, one millionth of a second per second exposure. And we used that type of equipment.

We also use for still photograph a polaroid-type camera which could be operated, a polaroid cell, which could be operated to give exposures of, again, about one microsecond.

The dangers with -- Well, the explosives that we use in mines, of course, have to be tested. Now this work is known as "permissible explosives" but they're not entirely safe under certain circumstances, and that's if breaks develop across the drilled hole where the explosive is inserted and these can be vertical breaks opening a gap vertically or across this way. So that the object of the whole thing was to sort of look at the processes of how the flame might start and think of ways of developing tests to make sure that the explosive would not ignite methane under those circumstances.

Q. Let me take you into the investigation section then where you spent quite a number of years.

A. Yes.

Q. I understand that you became during your time there the senior scientific officer?

A. Yes.

Q. I assume from the description that you have in your resume that this was the section that was responsible to go to and carry out any necessary investigations in the event that there was a mine incident, in particular, mine explosions.

A. Yes. It developed because in the late 1950s, there were quite a number of explosions in British mines, not particularly intensive ones, but small explosions. But there had been in about 1951, there had been a very large explosion which killed 81 men, but smaller explosions had occurred during those 1950s, particularly around about 1957. And hitherto, people, if the inspector wanted to -- the mines inspector wanted scientific help in determining the cause of the explosion, he would ask for help from people in the laboratories, and they would be seconded to do this work.

But it was decided round about the late fifties that that would be an advantage, to have one section which concentrated on this type of work. And they would be able to respond very quickly to any call for help. So this section was set up, and I was recruited into that section a year or two after it started, in 1960.

And the set-up was that -- obviously, we didn't just sit around waiting for explosions to happen. We had other work to do. And we did research work or any other minor examination of equipment that might occur. But if an explosion occurred, a mine explosion, the local Mines Inspector would be informed immediately, and he would inform the Chief Inspector or Deputy Chief Inspector of Mines, and he would decide whether he required help, scientific help, which he almost always did call us in. And he would call us in straight away and we would drop everything that we were doing. We had equipment all ready, and we would go off to the mine as soon as possible. And sometimes we had to wait until the rescue teams had been in and recovered the bodies et cetera, if anyone had been killed or -- and by this time -- we didn't wear breathing apparatus. We weren't trained in that aspect of it. We had to wait until the ventilation was recirculating and it was safe to go in or relatively safe to go in. Because sometimes the roof conditions, obviously, were a bit dangerous. But we took a calculated risk there. The inspectors wouldn't certainly let us go in if they thought anything was going to happen to us.

But that was the set-up. An immediate response to the investigation, so that we would be there, either the same day or the following day, and we would start our investigation.

Q. In your resume you say that you were involved in the investigation of every mine explosion in England but one.

A. Yes.
Q. And the only reason you weren't involved in that one, you were on holiday.
A. Yes.
Q. In fact, would it be fair, sir, to suggest to you that on your knowledge of the mining industry and people involved in it that you would probably have investigated more mine explosions than anybody else alive today?
A. Yes, I think so, yes, probably just because of that particular set-up probably, yes.
Q. All right, in addition to investigating the mine disasters that you've listed in your resume, you said you did research while in between waiting for the call.
A. Yes.
Q. I understand that that research included research into the accumulation of methane in cavities?
A. Yes.
Q. And also a study into how coal dust particles burn and the burning times of coal dust particles.
A. Yes, yes.
Q. Let me take you, before we get into the specifics of Westray, tell me about some of the mechanisms of a methane ignition, particularly in cases where there may have been layering of methane.
A. Yes. Some of this will obviously cover old ground

because yesterday we saw the demonstration of a methane explosion, and the notes were very useful in that respect that were given with that demonstration. But roughly, the limits for methane air, methane to burn when mixed with air, are roughly five parts of methane to 95 of air and 15 parts to 85 of air. That's roughly 5 to 15 percent of methane. So those are the limits. It's got to be mixed within those limits before it can burn or explode.

Q. What about the temperature to ignite methane?

A. You need about five hundred and -- I think the figure is 537 degrees Centigrade or 1000 Fahrenheit. That's a red heat. We're looking at on a surface of that kind of heat.

It can also be ignited by electrical sparks, frictional sparks, and open flame. Those are the main sources of ignition.

But I've listed in my report -- this is not an exclusive list, but the main things that would occur in a mine that would ignite methane. And these include the friction ignition such as rocks falling on rock or rock falling on steel, or rock being cut by metal where sparking occurs at the pick face.

Q. Let me, in fact, focus on that or a moment. Tell me the tendencies or the type of sparking or flaming that we

would get, for example, if you had sandstone with quartz inclusions. What would you -- and I'm talking now of the frictional work of a pick on a continuous miner.
A. Yes, the quartz in the inclusions in the sandstone have a very high melting temperature so that the picks rubbing on the quartz can cause it to be raised to a high temperature before it starts to melt. And so you get a hot smear of molten quartz on the surface of the rock which is sufficiently hot to heat any methane and ignite it that comes in contact with it, provided it's within the thermal range that I mentioned.
Q. So if it's sandstone, sandstone has got quartz inclusions in it.
A. Yes.
Q. These are fragments of quartz.
A. Mmm.
Q. And if a pick then were to hit sandstone, that's likely the mechanism by which you could get temperatures sufficiently high to ignite methane.
A. Yes.
Q. Tell me now about pyrite.
A. Yes, pyrites is as well, sandstone pyrites, is a well-known source of frictional ignition. In fact, I mentioned earlier the large scale explosion that happened in 1951, I think it was, at Easington Coal in England,

when that -- 81 men were killed in that explosion which, incidentally, developed into a coal dust explosion and covered about nine miles of roadway.

Q. Nine miles of roadway?

A. Nine miles of roadway, yes. But that was attributed to the ignition of the methane air which triggered the whole thing off by the blunt picks of the coal cutting machine striking pyrites. But the mechanism was somewhat different to the one I've just described for the quartz inclusions.

They found that grinding the pyrites into a powder at temperatures round about 200 to 300 degrees Centigrade could cause a hot spot on the -- or cause the powder to heat, which would ignite the powder itself. That in turn could ignite the methane. So it was a different type of mechanism. And the tests after that explosion showed that it wasn't very difficult to ignite methane air mixtures, provided you had blunt picks on the --

Q. So blunt picks and pyrites you can get -- and the presence of methane?

A. Yes.

Q. You could get an ignition of methane with a lower initial ignition temperature of the pyrites?

A. Yes.

Q. That would cause the pyrites to ignite and then that

would cause the methane to ignite?
A. Yes.
Q. It isn't the same mechanism as a hot smear?
A. No.
Q. This would be the burning of the pyrites particles themselves?
A. Yes. I've mentioned the 51 -- in fact, work was also done at the Safety in Mines Research Establishment just before the war. The work was published in, I think, 1938, '39, in the transactions of the execution of mining engineers in which they had already discovered that particular mechanism and they had published a paper giving the results of the work.
Q. So that's well established?
A. That's well established, yes.
Q. But I take it -- you mentioned the fact that blunt picks.
A. Yes.
Q. And I assume, therefore, from your answer that if you allow the picks on your cutting machine to become blunt that that is going to increase that possibility?
A. Yes, yes. In fact, it increases the possibility for quartz inclusions as well.
Q. So that it is a significant matter to ensure that the picks on your cutting machine remain sharp. And in

today's technology, I understand they have a tungsten --
A. Carbide.
Q. Carbide tips. Those continually should be replaced if they start to become blunt?
A. Yes, indeed, yes.
Q. All right, assume for a moment that you get a methane ignition. Tell me about how that can cause the methane to expand.
A. Well, it's really a question of temperature. Once the methane mixes to ignite, the temperature increases and that produces a high pressure, and that pushes the gas out. So that you get an expansion of the original volume of gas. It really follows quite well known physical laws, a combination of what is called Boyle's Law and Charles' Law, where the original pressure and volume divided by the temperature will equal the new pressure and volume and temperature of the ignited mixture. And it's a fairly easy calculation to show that theoretically the expansion that you could achieve is between seven and eight times the original volumes. That's in ideal conditions.
But in actual practical situations, for example, in a mine roadway, you get heat losses to the surface, back pressure releases elsewhere, so that an extension will occur, but it won't be the seven or eight times. It will

be maybe three, four, five times.
Q. What do we know about if you have a methane layer along the top of the roadway, what do we know about its burning characteristics, depending on how high and how concentrated it may be at the roof level?
A. Yes, these can vary. The unfortunate thing is that although a lot of work was done on the formation of roof layers, nobody -- not many people got around to igniting the layer, so that the information on the actual burning of layers is fairly limited. As far as I'm aware, there's very little published. But one of the -- some of the work that was published was published by the U.S. Bureau of Mines, and they had a relatively short layer, about 25 feet long. But they released the gas, the same amount of gas, at floor level and mixed it in a uniform mixture, and then released it at various sites up the roadway until the last one was six inches from the roof. And when they ignited it, they measured the flame speed and the pressures involved, and the lowest flame speed was the layer near the roof.
Q. So if gas is released near the top of your roadway, this is a valid experiment -- if gas is released near the top of the roadway, it will tend to burn slower initially?
A. Yes, it depends -- it's a fairly complex sort of

situation because the concentration of the layer will be from maybe pure methane or something between that down to the bottom of the layer where it will interface with the mine air. So you get a concentration gradient across the layer. And part of that gradient will be in these limits between 5 and 15 percent. And a lot depends on just the steepness of that gradient across the layer as to how it would behave.

But if the flammable part of the layer is relatively thin at the bottom of the total layer, you will get slow burning because it's a kind of diffusion effect. You have to mix the methane with the air in the roadway and get it the flammable limit. And that can be a fairly slow flame. So there's a whole range of speeds at which the methane could burn.

Q. Once we have --

A. If I might just -- this is not only for layers but for mixtures of methane under various conditions. So you can get anything from a few centimetres per second burning slowly all in the formation of methane. Or if you get a whole roadway full of mixed methane that is in, say, the flammable range in the middle of the range, you can get 800 meters per second. So there's a whole range of speed at which the methane can burn.

Q. If I'm understanding you correctly, and correct me

if I'm wrong, then if we have a thin but highly concentrated layer with not much of a mixed zone as part of it, that will tend to burn much slower than if you've got a thicker layer at that point in which the five to 15 percent zone is also much thicker.
A. Yes.
Q. So that if, for example, we have a thin layer that has widened out, the further down you go, the faster the flame may go?
A. Yes.
Q. Let me ask you about this: If you have a long, straight area where this happens, is that the phenomenon that, in fact, occurs? You used the phrase with me, "the runout."
A. Yes, you get -- As the flame expands, it pushes the air in front of the flame head and you get pressure waves developing and those pressure waves heat the air in front of them, and so they tend to go faster as the explosion progresses. So that eventually those pressure waves which are being given off from the front of the flame build up on each other and produce a shock wave, which is a steep-fronted wave of high pressure dropping down quite sharply.
Q. Let me just stop you there for a second. I want to make sure I got the first part of that. As the methane

is burning, it, of course, creates a pressure wave ahead of it.
A. Yes.
Q. Because of the expansion.
A. Yes.
Q. The pressure wave itself heats the air.
A. And the --
Q. And the methane.
A. And the burning methane as well, yes.
Q. Which allows the methane to burn faster.
A. Yes.
Q. Because the fuel now is pre-heated almost.
A. Yes.
Q. So the flame now starts to travel faster.
A. Yes.
Q. That puts out more pressure waves.
A. Yes.
Q. The pressure waves begin to build up on each other going down that roadway.
A. Yes.
Q. And then we've got a shock wave.
A. Yes.
Q. All of a sudden that's a big much pressure gradient.
A. Yes.
Q. And then what happens, assuming you've got a rundown

like in a mine roadway?
A. The speed of the whole thing can just increase quite rapidly the longer the run-up because the pressure produced is greater and the flame speed is proportionate to the pressure.
Q. If you have enough area to allow this run-up to occur, what ultimately happens?
A. Well, it will continue until you run out of fuel. The shock wave that's being produced will continue and slowly attenuate when it's no longer being fed from behind.
Q. Now I'm not suggesting that this happened in Westray, but what if you don't run out of fuel? What if it just keeps going?
A. Yes, well, in the ultimate, and this is very rare, this phenomenon can increase, the pressure can increase in the shock front, and there's enough energy in that shock front to actually ignite the gas on the spot as it hits it.
Q. Even before the flame gets there?
A. Yes, so you get another flame front produced and this reaction is at the same place as the shock wave so that the two are together, and that is a phenomenon known as detonation, which is a very short but very high pressure zone.

Q. That's a really big explosion.
A. That's a really big explosion, yes.
COMMISSIONER Mr. Merrick, can I just ask one brief questions here of Mr. Brookes? The methane on the roof is, as you said, in varying concentrations. It could be almost pure methane at the top coming down to the explosive between five, 15 percent.
A. Yes.
COMMISSIONER And then down there to the non-explosive.
A. Yes.
COMMISSIONER If you have the explosive methane cushioned between two insulators, how does it get to explode in the first place or ignite?
A. Well --
COMMISSIONER Do you see what I mean?
A. Yes. The ignition would occur at some other point which would, for example, if the methane were being released out the coal face and streaming up, there could be some mixing occurring as it streamed up.
COMMISSIONER And work itself into the flammable section, I suppose.
A. Yes.
COMMISSIONER Okay.
A. And then that would ignite.
COMMISSIONER Okay, thank you.

A. A good point.
MR. MERRICK I assume that wherever we've got a high concentration of methane, whatever you take it to be, 50 percent, 90 percent, there always must be, perhaps very small, but there always must be that zone between it and air in which the percentage has to pass between five and 15 percent.
A. Yes.
Q. Okay, and if you've got that in the vicinity as you described where you might have had a pyrites ignition, then it would travel up and go from there.
A. Yes.
Q. All right, I understand. What do we know about how much methane it might take or require -- Well, let me back up. We've heard evidence about how these pressure waves can kick up coal dust and that coal dust itself can then become involved in the explosion. I'm going to talk about that in just a second.
Do we know how much methane it would take as an ignition source itself burning to be able to generate a coal dust explosion?
A. I think, from memory, I think I've seen the figure. It's quite low. I think it's only about one and a half cubic meters.
Q. Of methane?

A.   Yes.
Q.   Not much.
A.   No.
Q.   All right. Now let's talk about coal dust explosions for a second.
A.   If I might just add something about another figure that comes to mind is that in Polish experiments, they were able to start a coal dust explosion with a roof layer of methane only two inches thick, but about 150, I think it was 150, or something of that order, long.
Q.   150 inches long?
A.   Feet.
Q.   Feet.
COMMISSIONER   Since we had our demo yesterday, could Mr. Brookes kind of relate that half cubic meter to the amount of methane that was used in the display there yesterday?
A.   One and a half cubic meters.
COMMISSIONER   One and a half, sorry.
A.   Yes. I'm just trying to think. It would be, in fact -- I'm thinking of a cubic meter. Let's think of a cubic yard actually is easier for me. 27 cubic feet and say that box that we saw was two cubic feet. It's something like 15 times that size, 13, 15 times.
COMMISSIONER   Still not a big --

A. Not a vast.

COMMISSIONER Okay.

MR. MERRICK And we're talking here about the amount of methane that would be required not in a container like we saw yesterday but just in a mine condition that would be sufficient to actually cause a shock wave to stir up the coal dust.

A. Yes.

Q. Whereas yesterday we didn't have to create a shock wave to do that.

A. No.

Q. All right. Let's talk about coal dust explosions for a minute. Let me begin with: How much coal dust do you need in the air for it to be able to ignited as part of an explosion?

A. Well, the figure I quote here, which I think I got from the Polish work, was a standard book on coal dust explosion by Professor Cybulski, and he quotes a figure of .04 kilograms per cubic meter of coal dust. It was sort of a low limit.

Q. That's your minimum.

A. Yes, or that's 40 grams. There's some useful information on the sheet that we were given yesterday and the figure there was .05 kilograms per cubic meter. So it's something of that order, but it's a very small amount of dust.

Q. Do we know if there's a upper limit? If you get so much coal -- Like we know with methane, that once you get over 15 percent, you no longer have an ignition problem.

A. Yes, again, this is open to debate. I think on that sheet they gave an upper figure of about 100 times the .05, which would be five kilograms per cubic meter. So it's something in that order, but it's difficult to measure. And some people say you can't measure it because you're not certain at that sort of concentration whether you've raised the whole dust into the apparatus that you're using to carry out the measurement. But I think the point is that the flammable range for coal dust is much greater than for methane air mixtures.

Q. Just to give me an idea, at the lower level, .04 cubic kilograms --

A. .04 kilograms per cubic meter, yes.

Q. Per cubic meter. How opaque would the air be? How much dust would there be in the air?

A. It would be very opaque. Something approximating to a miner's cap lamp bulb. You wouldn't be able to see that light at a distance of about two meters.

Q. So if a miner were standing away from me two meters away with his cap light on, I probably wouldn't be able to see the cap light.

A. And he wouldn't be able to breathe. He'd have to get out somewhere else in that atmosphere, so it's very much greater than the normal dust present in the mine anyway.
Q. Now we've heard evidence and we're going to hear more evidence about the amount of incombustible material that you have to mix with coal dust to make it inert.
A. Yes.
Q. We know in our legislation it requires incombustibles of 65 percent.
A. Yes.
Q. As a general rule, what sort of percentage of incombustibility is it your experience and your understanding that you should have to inert coal dust?
A. Well, in experiments carried out to find the inert material required from -- It's based really on the volatile content of the coal, things like methane that are included in the coal and tars.
Q. Propane?
A. Yes, there's a lot of -- there's a whole range of gases contained in the coal, which those are known as the volatile contents, the volatile content of the coal. When you drive those off, you're left with the carbon residue plus any mineral that's present in the coal. But the experiments show that it depends quite largely on the

volatile content of the coal under -- up to about 20 percent volatile. The curve goes from zero, so the coal won't explode. It doesn't really need any inerting. And at about 20 percent and above, fairly level above that, just going slightly at around about 60 percent inert. So if you take 65 percent, you're just above that level, but it doesn't give you a lot of margin for error.

So in the United Kingdom the amount of inerting required is based on the volatile content of the coal, and so it can go up higher than the 65 percent.

If the volatile content -- speaking from memory, if the volatile content is about 35 percent, they go to about 75 percent inert required.

Q. So the coal dust has in it the gases that are themselves very flammable.

A. Yes.

Q. And the more gas it has in it that's flammable, the more inerting material you obviously need?

A. Yes.

Q. Okay. And I assume that that is the same reason why you often see regulations enacted that if there is methane present in the general body of air, not in the coal dust itself, but in the general body of air --

A. Yes.

Q. -- you must increase the percentage of your inerting

material?
A. Yes.
Q. Because methane in the general body of air will act almost the same as methane in the coal particles themselves?
A. That's right, yes.
Q. Okay. I've understood that. Now once you get coal dust ignition, you've got a shock wave that has thrown up into the air enough coal dust?
A. Yes.
Q. And the coal dust itself has become a part of the explosion. Do you need methane to continue that on?
A. No. If there is insufficient inert material raised when the coal dust is raised by this shock wave or pressure wave ahead of the flame, if there's insufficient inert material, the coal dust will be ignited by the methane flame, and you probably get a period when the two are continuing together. But if the methane at that stage runs out, you've run out of fuel, the coal dust can then continue to burn on its own and then the pressure produced by that coal dust flame is sufficient to be self feeding and raising more dust from the surface of the mine roadway. This is why, harking back to the Easington Colliery explosion, it was able to do that and travel with less distance of --

Q. Nine miles.
A. -- nine miles.
Q. Obviously you wouldn't have had nine miles of methane. That was nine miles of coal dust.
A. No, no, and this is the reason that if the explosion is extensive that it's very unlikely that it's all due to methane.
Q. Once you get a coal dust explosion, tell me about the difference in characteristics that we may get as far as the zone of burning and the length of burning?
A. Yes. We -- the flame front in a methane explosion is much thinner. The actual flame moving through the gas air body is much thinner. So if it's travelling fast, it's only in contact with the roof and sides or the surfaces of the roadway for a short period of time, so that you can get a methane explosion occurring in a mine and you go down afterwards and not see any sign of burning to the naked eye.
But with a coal dust explosion the actual extent of the flame is very much greater. It may be several hundred feet -- well, it's hard for me to say that -- it can be of that order because the -- it takes time for the coal particles to burn. You've driven off the volatile material which is ignited but the coal residue, that which is mainly carbon, is still probably burning and

it's a much slower process, that. So you get a longer burning zone in a coal dust explosion.
Q. And what do you get as far as force and pressure? Which provides a more destructive force?
A. Well, that's a bit difficult to say because it depends on the concentrations involved. But the -- because the limits of ignition for coal dust are very much wider than for methane, it's likely that you would get more energy produced in the coal dust explosion, weight-for-weight, than you would in the methane air explosion. That's not to say that you can't get tremendous damage done by methane air explosions alone.
Q. All right. One last question on this point. I assume that in a coal mine with a conveyor system if an explosion should occur that now involves coal dust, the conveyor roads are the more likely path of it, all other things being equal, because that's the area where you're most likely to have the most fuel --
A. Yes.
Q. -- for the explosion?
A. Yes, because it's difficult to deal with the coal dust present on the actual conveyor because it's there all the time. If you're conveying coal, you've got dust on that conveyor and that's not mixed with inert material, so that if an explosion occurs, that can be

raised off the conveyor belt and propagate an explosion.
Q. All right. Thank you. This is one point we could break for the mid-morning, Mr. Commissioner.
COMMISSIONER Okay, fine. Let's take our morning break. 15 minutes, thank you.
INQUIRY RECESSED (TIME: 11:05 a.m.)
INQUIRY RESUMED (TIME: 11:22 a.m.)
COMMISSIONER Mr. Merrick?
MR. MERRICK Thank you.
Q. Mr. Brookes, let me bring you to the topic of investigating a mine explosion. To begin with, just in general terms, how do you go about carrying out such an investigation?
A. Well, the first thing -- really, you need to establish three things in general in an investigation. You need to know the actual extent of the explosion path. Once you've established that, you can -- you know that the source of ignition is somewhere within that area, so you look for possible sources of ignition. And then you want to know really where the fuel came from. Usually, as we've said, that mine explosions usually start off as methane air explosions and sometimes develop into coal dust explosions. So those were the three things.
And in my experience, mainly in deep mines with vertical shafts, the explosion itself was confined to

somewhere within the mine. It didn't exit through the portals as the case at Westray. So it occupied a definite area or a section of roadways in the mine, so you had to look within that area. And, as I mentioned previously, that the methane explosion can travel fast in certain circumstances and so walking along the roadway, it may not be possible to see actual signs of burning or, indeed, there may or may not be great damage. So what we did was to collect samples of material from the sides of the roadway in a systematic manner. We would fix a date and point, lay out a long 100-yard tape or whatever and --

Q. This is in a typical investigation?

A. Yes. And then we would go along and we would look for anything which might show signs of burning, not perhaps to the naked eye, but when examined under a microscope. For example, if you got a little piece of a string that were left. Sometimes surveyors use string in their work and leave it hanging from the roadway, and you could pick a bit of string, and it may not appear to be burnt until you sort of look at it under the microscope and you see the signs of burning. So anything of that nature that was fixed in position, hadn't been blown about by the explosion, was still where it would have been tied or a piece of wood, wherever it was in its original position, we would collect, and a subsequent examination of that material would tell us where the flame had been.

Also at the same time we would gather samples of coal dust, brushed coal dust, from vertical surfaces, usually from the arches supporting the roadway. We'd collect a few grams of coal dust, and that would be examined to see if it had been burned during the explosion. While we're doing all this, we would obviously be making notes about the direction of blast, particularly where heavy objects, if they had been moved in a particular direction, if arches had been moved in a particular direction and, indeed, anything that had moved from its original position which would give us an indication of the way that the explosion was travelling.

So that was the first thing, to do the systematic examination of the roadway, making as many notes as we could and collecting as many samples as we could.

Q. I take it that the reason you're looking for evidence of burning is that that obviously tells you if flame has gone by that portion of the roadway?

A. Yes. Yes. You said that you would try to take dust samples from vertical surfaces. Why would you prefer, if possible, to get them off vertical surfaces?

A. Well, the vertical surfaces would have less dust on them in the -- before the explosion, being relatively clean compared with the floor of the mine roadway. And if there were small deposits, they would probably be displaced by the explosion so that the dust that we collected after the explosion would probably be dust that had been impacted onto the supports or had settled out and settled on that part of the mine. So that if we then examined the dust, the post-explosion dust, we could determine the degree to which it had been burned. Where if we had picked samples from the floor, we might have been picking stuff that was underneath the top layer. And that might include unburnt material and would give us a wrong sort of measurement.

Q. All right. When you're looking at -- you say you're also looking at the signs of force, you know, how things have been moved around in a mine --

A. Yes.

Q. -- how important is it or how usual is it to see signs of force going in one way but also to see signs of something else being moved in another direction?

A. Yes, that is not uncommon and can be misleading. It can be misleading in certain circumstances, but because particulary lighter objects can be moved in that way because you get -- the shock wave can be reflected from surfaces and moved the other way. As an analogy, perhaps if you throw a stone into a pond, you see the ripples moving out from the center of that point at which the stone has entered. And if there's a log in the pond, when those waves hit the log, they'll move in the opposite direction. It's just a reflection, basically. But you can -- that -- if there are bends in the road, as at Westray, where you get bends there and there [indicating on chart], that sort of areas, you could get reflected shocks from those corners, for example, or from any of -- the dead end is what you find on these roadways.

Q. So that the forces taking place during an explosion will not necessarily all be in the direction of the explosion?

A. No. Another point is what -- once the flame has died, rapid cooling occurs. The heat, the gas that is left, the burned gas or products of the explosion that are left cool fairly rapidly. That heat is absorbed by the mine surfaces. So you get a partial vacuum created which sucks the air back in, so you get this sort of movement.

This is very obvious in surface galleries such as the ones that -- or the one that we had at Buxton where you have a, as I mentioned, a gallery 400 yards long with a closed end and you create a dust explosion in that gallery. It reaches the end and then the gas cools. A partial vacuum is created so you suck dust back into the tunnel and then that pressure wave that goes back in reflects on the closed end of the gallery and pushes the whole thing out. So you get this kind of breathing of the tube. And this sort of thing can occur underground.

As an example of this, I might mention -- I wasn't -- it was after I retired, but someone told me that by the side of the gallery someone had left a huge or a large wooden crate and they conducted an explosion in the gallery. And as the pressure wave came out, it created a vacuum which sucked the crate into the gases that were coming out. Then the crate was sucked back into the gallery and the next instant it came out as matchwood. So those were the sort of forces involved.

But this is the -- the point -- the whole point I'm making is that you can get these, what I've called, "rarefactions," which can move lighter objects in different directions.

Q. So when we're looking at physical signs of damage, there may be contradictory signs there. What should we be looking for in order to know the direction of the explosion itself?

A. Yes. Well, we're looking for fairly heavy objects that have moved that are not likely to be moved by this other movement. For example, the heavy supports which have been knocked down to floor level or bent towards the direction of the blast. But even then you've got to be very careful about looking at those, because with a support you don't know whether the bottom of the support has been hit and it's tilted it that way or it hit it at the top and tilted it that way. So, really, sometimes you need to have an examination of the base of the support.

Q. I take it that what's important is when looking at all these signs of physical movement, particularly with the heavier objects as you've indicated, it's important to try to determine the general trend of movement?

A. Yes, that's exactly the point. The general trend is the important thing, yes. And you can --

Q. Not --

A. You can ignore slight variations in that if -- or contradictory evidence of small objects moving somewhere else.

Q. All right. And do you also look -- you say you look for the source of gas, if possible.

A. Yes.

Q. Yes, sometimes -- indeed sometimes the gas might be still forming and be still there and building up again as it was to the pre-explosion level. And sometimes we did simulation. If there was a feeder of gas that we were able to find coming from a fissure in the roof, for example, we might try to reconstruct those conditions and form -- if that was forming a methane roof layer, for example, we would see if we could form that layer again and this, in fact, was done, at one of the explosions that I helped investigate. Obviously, you've got to be very careful about the conditions when you conduct this type of experiment to make sure that there is not going to be another ignition go off.

Q. You want to reconstruct it but not completely. In this case, of course, it was impossible to get into the south -- that would only happen where you can get back into the mine --

A. Yes.

Q. -- in a safe environment?

A. Yes.

Q. All right. One last question that I forgot to ask you about coal dust explosions. How likely is it that the initial ignition could have been purely coal dust?

A. It's very unlikely but not impossible. But the -- really, that probably one -- there were very few things that would cause that to happen. One is a blown out explosive charge of a non -- possibly a non-permissible explosive which would create a dust cloud and also provide the heat to ignite the dust.

Another possible cause which I've put in my report is that if, for example, you had a mine car full of coal with a lot of dust in it and that ran away, tipped over and the same time severed an electric cable so you've got a cloud of dust formed by the tipping over of the mine car, you severed a cable, you produced quite a strong electric arc. This would ignite the coal dust. And so that could initiate a coal dust explosion. I can't quote an example which I've had personal experience of in an investigation.

Q. This doesn't happen that frequently?

A. No, this is very rare indeed. But the example I was going to quote was that we did invest an explosion of cornstarch which is the stuff they make custard powder from and they overfilled a hopper which burst the top off the hopper, and that broke the electric conduit, creating an electric arc, and that ignited the cornstarch dust. So that's a typical example of a dust explosion that can start electrically. But, as I say, they're very rare underground.

Q. All right. Let me bring you now to the investigation that you conducted at Westray itself. Tell me about -- you went down into the mine on one occasion yourself?

A. Yes.
Q. And some of the sampling that was done was done by others and not yourself.
A. Yes.
Q. And, in fact, you say in your report that your -- you had limited both time and area in which you could yourself carry out observations. How did that come about?
A. Well, on arriving at the mine, we were told that the conditions were very dangerous underground and that we would be really foolhardy to go underground at Westray. But we -- on discussing this, we thought -- I particularly thought I had come 3,000 miles, and I didn't want to go back without going down that mine. But I must admit, I had my doubts about it and it was sort of touch and go whether we went down.
But -- and even, after some discussion, it was agreed that we would go down if we were accompanied by a team of draegermen who were wearing breathing apparatus, and that we would carry an oxygen set, breathing apparatus, with us and if an emergency arose, that we would put this on and hope we would get out.
I think the possible danger there was that there might have been carbon monoxide remaining in those sealed-off areas which, if there had been a fall or

something of that nature, that could have been expelled into the roadway, and we were in the intake roadway and that would have been, obviously, very dangerous.

But nevertheless, after some discussion, it was agreed that we were -- we would go down. I believe the Department of Labour weren't keen on us going down because of the danger.

And as a last straw, the acting mine manager told us that we were going entirely at our own risk and that if any man wanted to drop out, he could do so. But being stout-hearted fellows, we decided to risk it.

And -- but because we were accompanied by the draeger team, that limited the time for which we could be underground. And, say, if it was a half an hour to travel down and half an hour to travel back, that limited roughly the time to about two hours, which isn't very long to get a climate as to the conditions and get your bearings and start doing work. So that limited my -- actually limited the extent of my investigation.

Q. So that was the reason for the time limitation that was imposed on you. There was also a sort of a geographical limitation imposed --

A. Oh, yes.

Q. -- on you?

A. Yes. Although we were in the intake roadway, we were advised not to go into the return because of more dangerous conditions that might occur there if -- the possible danger of falls or gas coming into the returns is what I understood.

And so at first our or my investigation was limited to the intake side of the roadway. But after the draeger team had been through, we were allowed to just go through the -- I think it was the No. 10 Crosscut into the return and just have a look in the return, around that area.

Q. So the extent of where you were able to physically observe would be going down the No. 1 Main slope --
A. Yes.
Q. -- to the No. 9 Crosscut?
A. Yes.
Q. You were then able to observe the main slope in the area of 9 and 10 Crosscut --
A. Yes.
Q. -- a short distance inbye of 10 Crosscut?
A. Yes.
Q. And once the draeger team had gone into the return and satisfied themselves there was a reasonable degree of safety, you were allowed in the crosscut and into short distances in the No. 2 return --
A. Yes, that is correct.
Q. -- in the vicinity of 10 Crosscut?

A. Yes.
Q. But that was it?
A. That was it, yes.
Q. And that is a very limited range for you to do the kind of investigation you would like to do?
A. Yes. I quote in my report that one of the last major -- not the last one but the penultimate explosion investigation that I was involved in Golborne Colliery in England in which 10 men were killed, the time we spent underground, and it was a more simple layout than the Westray layout and of less extent. We spent about 14 man-hours -- 14 man-days, I should say, 14 man-days for the scientific staff involved for those alone, not counting the time spent by inspectors and other people down there. So it's 14 man-days in carrying out this investigation as opposed to two hours at Westray.
Q. All right. So with that explanation as to the limits that you were operating under, let me take you down that No. 1 Main and we'll review your observations as we go down. And then we'll talk about the sampling after that.
Just give me one moment to get the -- make sure I've got the right books in front of me. We are going to need 59, Exhibit 59 which is the booklet of the photographs that we see on the wall. And, in addition, you want to

refer us to some additional photographs that were taken, some during the incursion in which you're talking about and others during the time that the RCMP went into and they are found at Tab 9 of Exhibit 73. Do you have those in front of you?

A. Yes.

Q. All right. Let's start down the No. 1 Main and we'll -- and tell me what observations you made as you went. And we'll be, in effect, following your report as well at pages -- Let me just find it here.

A. Page 7, I think.

Q. You may be right. Yes, you're right, starting at page 7. Okay, what observations did you make that were of assistance to you in developing your opinions that you've expressed in your report?

A. Well, the first one, we've got No. 7 Crosscut, which is Photograph 35.

Q. That's under tab 9, okay.

A. There was two vertical girders joined by a horizontal roof girder which appeared to have been blown out of the entrance to the crosscut.

Q. Now let me just get an orientation here. That's Mr. Smales, I believe, in the foreground, is it?

A. Yes, it looks like Mr. Smales, yes.

Q. And are you telling us then that we're looking down

the No. 1 Main?
A. Yes.
Q. And to the right of Mr. Smales or to the right of the photograph would be the entry to the crosscut over to No. 2.
A. Yes, and this, yes, this girder that you see coming over -- not over Mr. Smales' head but in that general direction there and the vertical bit which is leaning, that appeared to have been blown out of the crosscut in the direction from No. 2 roadway to No. 1 roadway.
Q. I see. So that that was a girder that had originally been in the crosscut?
A. Yes.
Q. And had been pivoted out?
A. Pivoted out, yes.
Q. Into the main.
A. Yes.
Q. So that footing that we see to the left of Mr. Smales, what would be the vertical part of the girder, would have been around on the right of the photograph.
A. Yes.
Q. All right.
COMMISSIONER 35?
MR. MERRICK Yes. So that that girder didn't just collapse into the picture as we see it.

A. No, it didn't.

Q. The vertical side of it pivoted out into the photograph.

A. Yes, that's what appears to have been what happened there.

Q. And that's what you were advised?

A. Yes.

Q. Okay, all right, let's keep going.

A. And then as we travelled down in the vehicle, I noticed concrete blocks, rubble against the left-hand side of the No. 1 roadway as we went down. And I was told that these were -- this was the debris from the seals in the crosscuts which were built of concrete blocks. These had been blown out from the direction of No. 2 main roadway, the conveyor roadway, into the intake roadway in which we were travelling and had hit the left-hand wall and had been deposited there.

Q. Do you have any photographs that indicate that?

A. I think, yes, in Exhibit 59, Photograph 2, is one typical example of that.

Q. Okay. Again, to get orientated, that's a photograph, and if we look to the right-hand side of the photograph, we can see the roadway going down.

A. Yes.

Q. So that's No. 1 Main going down, and the debris that

we see in the foreground is -- Sorry, the crosscut, the No. 1 Crosscut would be off to our right.
A. Yes.
Q. So that debris would have been blown out of that crosscut to the right and impacted against the far side of the main.
A. Yes, that's correct.
Q. Okay.
A. Now Photograph No. 7 is debris in No. 1 Main at 8 Crosscut but the orientation of this photograph looks as it it's been taken from the crosscut.
Q. But that is illustrative of the kind of debris that would be in the No. 1 Main.
A. Yes, they seem to be the exact concrete blocks and broken stone work there, yes.
Q. I'm assuming that that sort of blocks and brick material may well have been what the stoppings had been built up in the crosscut.
A. Yes.
COMMISSIONER That's pretty heavy material, is it, Mr. Brookes?
A. Yes. These stoppings within the crosscuts were built of concrete blocks.
COMMISSIONER They're not something you could pick up with one hand or anything like that, would they be?

A. No.
MR. MERRICK All right.
A. And then we didn't stop at each of these crosscuts. We were travelling in a vehicle and we were saying, look, that's the debris from this particular crosscut. We got down to what had been the air crossing at No. 9 Crosscut and I was a bit lost then because there was no, obviously no air crossing left. I was told that had been destroyed, and this was the debris from -- pointing out sort of the debris on the floor, this was the debris from the actual air crossing and this sort of debris is shown at 42.
Q. This would have been shoved off to the side by that point or a little out of the way.
A. Sorry, Mr. Merrick?
Q. This debris would have been sort of cleared partly out of the way at that point.
A. Oh, yes.
Q. It wouldn't have been as it fell?
A. No, I think not, yes. I think it had been cleared, yes.
Q. And is that the same thing we see in Photograph 41?
A. Yes, that's the same type of thing, yes.
Q. And, again, you are basing this on what you were advised. On this entry, you were accompanied by mine

officials?
Q. You had the draeger team.
A. Yes.
Q. And you say in your report, I think it was Mr. Phillips and --
A. Mr. Phillips, yes. There was Mr. Smales, Mr. Phillips, and Mr. Currie, who was the acting mine manager.
Q. Yes, and they were the ones telling you this information?
A. Yes.
Q. Okay, all right, so that's what the air crossing looked like at the end. What else are you showing us?
A. Yes, 43 shows the temporary seal that had been put on No. 9 Crosscut.
Q. So what we're looking at in Photograph 43 under tab 9 is we're standing in the No. 1 Main looking straight at the entry into the Southwest district at the 9 Crosscut.
A. Yes, that would be the C-1 roadway.
Q. So they blocked that off with plywood covered with plastic sheeting?
A. Yes.
Q. And then that white tubing would have been coming across into the return airway.
A. Yes, that's what I understand, yes.

Q. All right. To vent off or to allow bleeding of the gas in that district, I guess. All right, so that's the stopping at the No. 9 Crosscut.

A. Yes. No. 49 is the same sort of thing at 10 Crosscut showing the temporary seal that had been put up and debris on the roadway there.

Q. That's a lot of debris.

A. Yes.

COMMISSIONER Photograph 49, is it showing the temporary seals being put up?

A. Yes, that would be the seal into the C-1 roadway.

MR. MERRICK At 10 Crosscut?

A. At 10 Crosscut.

COMMISSIONER Okay, thank you.

MR. MERRICK It was in place by the time you got there?

A. Yes.

Q. Okay. What other --

COMMISSIONER There's some confusion there, Mr. Merrick, because there are now two Photograph 49s. In Exhibit 59, there's a Photograph 49.

MR. MERRICK Yes.

COMMISSIONER That's what threw me off a bit.

MR. MERRICK Okay, that's something that may happen in that the numbers on the photographs under tab 9 are the numbers that were originally placed on the -- They have come out of the collection of photographs compiled by the RCMP. That's their numbering system. And the ones in Exhibit 59 are numbered merely in sequence according to the big plan on the map. So we've overlapped occasionally.

COMMISSIONER Okay, okay.

MR. MERRICK I think what we'll do is keep it straight on the record by making sure which exhibit we're referring to each time.

COMMISSIONER Yes, that would help, yeah.

MR. MERRICK Okay. All right, what's your next observation that you made?

A. Well, I was shown, again, a piece of concrete in No. 10 Crosscut which had been blown in the direction of the No. 2 conveyor return roadway, so that where all the other crosscuts from 8 up had gone from the return roadway to the intake roadway, the one at No. 10 Crosscut had come the other way.

Q. All right, so that had blown from the No. 1 into the No. 2?

A. Yes. Then just below inbye of No. 10 Crosscut, this was a bit confusing to me because corrugated sheet cladding, some of it bent around this portion in the outbye direction which seemed contrary to the evidence from the arches in that area which is shown on Photograph

57 of this main.

Q. In Exhibit 59?

A. No, in the main.

Q. Yes, you're right, okay. I'm getting confused myself. We're under tab 9, Exhibit 73, Photograph 57.

A. Yes.

Q. Oh, I see.

A. These supports here appeared to be leaning downhill in the inbye direction and the cladding in that particular area seemed to have been bent in that direction also.

COMMISSIONER Would you know, is that photograph being taken towards the roof from the floor of the mine, floor of the roadway, or --

A. I don't know. It appears to be taken from a higher level, I would have thought, but I'm not sure about that.

MR. MERRICK But the girders are leaning one way and the cladding is bent the other way.

A. Yes.

Q. What's your explanation for that?

A. Well, it's not easy to explain, but the cladding material, under the forces we're talking about to move these very heavy supports, it's relatively light material and it could have been the way that it was bent by the movement of these arches. But I can't really explain it

fully.
Q.   All right. You say though that in reference to this, and this is at paragraph 4.7 of your report, just the last two sentences of that paragraph: "In the area about 175 feet inbye of No. 10 Crosscut..." So you've got in past No. 10 Crosscut inbye.
A.   Mmm.
Q.   "...the blast appeared to have moved the girder supports in the inbye direction."
A.   Yes.
Q.   And that's what this photograph is indicating, is they're leaning in the inbye direction.
A.   Yes.
Q.   But cladding sheets in this area had been impacted in the inbye direction, although we see some here going the other way.
A.   Yes.
Q.   All right.
A.   Sort of bit of confusion about what had actually distorted the cladding sheets in that whole area.
Q.   Can that be explained by this business of the different forces that can happen during an explosion and how they may be coming back out and moving lighter items?
A.   Yes, it may be a possible explanation. That's the sort of thing that might happen.

Q. All right, what other observations did you make?
A. Well, then I took samples of dust, just a few samples, in this intake roadway and these are listed in the tables that I give in the report, Tables 1, 2 and 3. And it was at this stage that we're sort of having a general look around mainly and looking for stuff to collect. But then it was suggested that -- The draeger team by this time were in the return and it was suggested that it would be safe for us to go through into the return roadway and just in the vicinity of between 9 and 10 Crosscuts and just have a look at that area, which we did.
I observed that the conveyor structure in the region between 9 and 10 Crosscuts had suffered some damage and it was pointed out to me at 9 conveyor drive -- 9 Crosscut that the conveyor drive unit had been displaced towards the No. 2 conveyor return and had moved slightly inbye. Photograph 41 of Exhibit 59, which shows the damage to the belt structure.
Q. Just let me get myself oriented here. We're looking down the roadway. We've got a lot of pieces of cladding material in the foreground. I see in the background what looks to be a metal frame tipped over on its side.
A. Yes.
Q. Is that what you're talking about?

COMMISSIONER That's not this here, is it?
MR. MERRICK No, a little more in the centre, back in the background.
COMMISSIONER Okay, I've got it.
MR. BROOKES It looks as if the -- It's difficult to tell from this photograph, but it looks as if the conveyor structure is being sort of blown, disintegrated just in that area.
MR. MERRICK Yes, and that's what the structure would have been made of, that kind of metal bracing.
A. Yes.
Q. All right. Okay.
A. And then, and I haven't got a photograph of this, but just outbye of No. 10 Crosscut, I noticed some of the flexible ventilation ducting, the sort of plastic-type ducting that was used in the ventilation of the entries, such as the SW 2-1 entry and throughout the mine. There was some of this type of ducting there, not being used. It had probably been left as the mine had developed, and this quite often happens with the ventilation ducting might just be left even though it's no longer required at that point. I observed that that had been completely burned out. There was just the spiral supporting wire left, which suggested to me heavy burning in that area.
Also a cable I noticed on the left-hand side of the

roadway that had part of its covering burned. And from previous experience, I know that quite often cables that have been involved in explosions, the type of heavy rubber-covered cable may not even show signs of burning to the naked eye, so I suggest that there might have been some heavier burning there in that region.

Q. All right, and those are your observations apart from sampling?

A. Yes, I also saw what I thought to be coke coal dust spattered on the flange of the conveyor structure just inbye of No. 9 Crosscut. And I took a sample of that dust, but later on I was unable to confirm, for reasons that perhaps I can give later on, I was unable to confirm that it was, in fact, coke. But in appearance, it looked to be coke.

Q. Okay, now we come to the samples themselves. You can put the photographs aside. Tell me about the sampling that Mr. Dooley did, Mr. Dooley and his draeger team did for you.

A. Yes, initially, as we had been advised that we weren't going to be able to go into the conveyor return, the No. 2 roadway, I asked or it was said to me that Mr. Dooley and his team of draegermen would be willing to take samples on my behalf in that stretch of roadway if I told them what type of samples I required. So I asked

Mr. Dooley if he would do this and I said if you can possibly get the samples from the vertical webs of arches or any vertical surface, that would be the best place to take them, or from conveyor rollers which would be quite clean while they were working and would be relatively clean so that any dust that settled out onto them would be post explosion dust in the main. So those were the types of samples that I asked him to get, which indeed he did as far as he was able, but he wasn't -- I found out subsequently that those types of surfaces that I had suggested weren't always readily available for him to take the samples, but nevertheless the samples that he did take I found very useful after explosion in the investigation.

Q. How did he collect the samples and by what means did he get them?

A. He brushed them into a plastic bag.

Q. Individual plastic bags?

A. Yes.

Q. All right, and how did he get them to you so that you would know where he had taken them?

A. Yes, when we returned to the surface, he gave me the bags which were numbered, which he had identified by a number, and he read out to me the location at which he had taken the sample and I noted, made a note of these.

In fact, the numbers that I give in the table are the numbers that Mr. Dooley gave to me.
Q. So that when we come to your tables, Samples Nos. 1 through 20 are the samples taken by Mr. Dooley.
A. They are, yes.
Q. And when he read out to you the locations from which he took those samples, I notice at the back of your report, Figure 2, you've got a diagram of the No. 1 and No. 2 Main.
A. Yes.
Q. With locations. Those are approximately --
A. Yes.
Q. This not being a --
A. He didn't specifically measure the exact location of the sample, but that didn't really matter too much. He said that he had taken them at regular intervals between No. 10 Crosscut and No. 8 Crosscut. So the numbers, again, are roughly regular spacing.
Q. And he would have told you what surface he took them off and where he got them?
A. Yes, the descriptions he gave to me. I give them in the Table 1.
Q. Are you satisfied with his collection method?
A. Yes.
Q. All right. You took some samples yourself.

A. Yes, sir, I took a few samples in the intake road. And in order not to confuse my -- If I was going to identify them, I didn't want to put numbers on my bags. So at that stage I didn't know how many samples that Mr. Dooley would be taking so I numbered my samples by letter. But in order to make it more simple, when I put these into tables, I later gave them a number of my samples.
Q. Now in addition to taking coal dust samples, and the samples that you took again are located on your diagram Figure 2.
A. Yes.
Q. You took Samples Nos. 21 through 24.
A. Yes.
Q. And Sample No. 33.
A. That's right, yes.
Q. And, in addition, you collected pieces of other items other than coal dust samples.
A. Yes, I took, as I mentioned, earlier, in the sort of typical investigation we tried to pick up materials that will show signs of burning. And so I was looking in the No. 1 Road, in the intake road, for samples of that nature. And so samples which are numbered No. 25 - 31 are listed in the table.
Q. All right. So these are other kinds of things. So

in total, exhibits -- samples numbers 21 through 33 inclusive you took, some of them being coal dust, some being other kinds of things?
A. Yes. Yes.
Q. And the last bunch of samples that are logged in your tables, you received a variety of samples from Mr. Smales over a period of time?
A. Yes.
Q. Had you requested --
A. Uhm --
Q. Sorry, had you requested any of those --
A. No.
Q. -- additional samples?
A. No, I hadn't. But Mr. Smales -- Mr. Smales made various entries into the mine afterward, and during the course of these entries he collected or took the opportunity of collecting samples which he thought would be useful to me and sent them over to me. And, in fact, those did quite often prove very useful in the areas outside which I had been. And they had -- yeah, some of the samples were in the No. 2 return roadway further outbye than the draegermen were.
Q. Okay. Let's talk about what you did with the coal dust samples to begin with. You would have sieved them, as you say, in your report?

A. Yes.
Q. So each individual sample would have been sieved between the two sieve sizes?
A. Yes.
Q. Why were you trying to get that particular range of sample?
A. Well, I was going to examine them by means of a normal light bench-top microscope with a magnification up to about x 50. And that range of particle size which I selected, that is between 125 and 250 microns, I have, in my experience, found that that's a handy size to examine, a convenient size to examine and that it will read and it shows well. If you get particles below that size or very fine dust, they are much more difficult to examine by this microscopic means.
Q. And what are you looking for?
A. I'm looking for signs of burning of the coal particles, signs that they have been affected by heat, have been in some cases converted to coke. And this is an indication that they've been involved in the explosion, that obviously they've been heated, the volatile material has been burnt off, and part of the residue of the carbon is being burned to produce a coke-like structure.
Q. And when you would look through the microscope,

you've got two plates at page 14 and 15 of your report, Plate No. 1 is, I take it, dust particles or coal dust particles that have not been exposed to heat or burning?
A. That's correct, yes. The --
Q. How do you know that?
A. Because I -- this was a sample of solid coal that I picked up myself at Westray from -- in the region of No. 9 Crosscut where there was a coal surface. And I broke some of the coal off in lump form. And I ground that coal and sieved it through the same size sieve, so that I would have a comparison of what was unburnt coal to coal that had been involved in the explosion.
Q. And this plate that we see, Plate No. 1, is what you would actually see when you were looking through the microscope?
A. Yes, these photographs were taken on my behalf at the laboratory in Sheffield of the Health and Safety Executive using their electron microscope, but at low magnification comparable with the magnification that I used. These particles wouldn't appear that size to me. It will be still smaller than that. That is another enlargement of the photograph. There's a scale given on the photograph which shows you the sort of size.
Q. All right. So that's unburnt coal?
A. And -- well, if I could mention the -- that unburnt

coal, if you look at those sort of square sort of rectangular sharp-edged type particles which is typical of crushed coal.

Q. All right. And Plate 2 shows another sample --

A. Yes.

Q. -- shows one of the samples from Westray?

A. This is, yes, Sample 9 from Table 1 which I took from Westray. And that, in my examination, I estimated that about 90 percent of the actual particles of that sample showed signs of burning.

Q. And you know that because of the appearance of those particles?

A. And if you look at those particles, you see that they're more rounded and they're a rougher type surface. That's typical of the coke appearance. And there are little holes you can see in them where the volatile material is blown out through the surface of the particle.

Q. All right. And so you did that with each of the samples?

A. Yes.

Q. You had --

COMMISSIONER This would be methane that was previously trapped in there?

A. Yes.

COMMISSIONER Okay.
A. Yes. And other -- the other gases that we mentioned --
COMMISSIONER Okay.
MR. MERRICK Now in your table you log occasionally stone dust particles.
A. Yes.
Q. Whether or not you also have found stone dust particles in your coal dust sample.
A. Yes.
Q. I take it we should not give any significance to the amount of stone dust that you did or did not find?
A. No, because I must say that when I first examined the coal dust samples, in the majority of cases I didn't see any sign of stone dust at all. But the -- I found that the particle size of the stone dust that was used at Westray was, in fact, below the particle size that I was examining. So it wasn't -- there was no significance in that. It meant that I wouldn't be finding coal -- stone dust particles in those samples except the odd one that might have just been a little bit above the normal size.
Q. Assuming that the stone dust being used at Westray was of the particle size you were told, you may well have been sieving it out, so there wasn't left in the sample that you would analyze?

A. Yes.

Q. I understand.

A. Yes.

Q. All right. Now let's -- having done that on the dust samples, and I take it on the other samples that you looked at, like pieces of rope, string, belt, that sort of thing --

A. Yes.

Q. -- you were looking for any signs of burning?

A. Yes, that was the objective looking at those samples, yes.

Q. And examining them, if necessary, under the microscope?

A. Yes.

Q. All right. Now taking all of those samples, let's go to your table and you tell me what you're able to conclude as to where, in that portion of the mine that the samples were taken from, flame travelled during the explosion?

A. Well, if we look at the samples at the number intake roadway, that's Table 3 --

Q. Yes?

A. -- the sample 25 which was a piece of synthetic rope fiber which was hanging from the roof -- I think we had to climb up onto something to get that particular one, outbye of No. 8 Crosscut. It was -- it appeared blackened and might have given one the impression that it was burned, but, in fact, when it was cleaned up, I found that it wasn't burnt. It was some deposit -- stuff that had been deposited post-explosion -- during the explosion. So that that indicated from that one sample that there wasn't burning in that area.

The similar sample at 9 Crosscut, between 8 and 9 Crosscut, showed that the sample was badly burned, the fiber ends swollen. Again, at 9 Crosscut, similar material was burned. Between 9 and 10 Crosscut plastic-covered cables -- a cable was burned. Wood splinters below 175 feet below 10 Crosscut had fiber tips burned. So this gave me an indication of where flame had been and where flame hadn't been. But by the time -- so it was obviously all around 9 and 10 Crosscuts that had obviously been burning there.

But on this No. 1 intake roadway, when I got out to take a sample between No. -- or the sample I examined, I think that was one of Mr. Smales' samples that he sent to me, that was between 5 and 6 Crosscuts, Sample 41, I found that again one of the synthetic rope samples, although dirty, when I cleaned it up, wasn't burned. And the other rope which I deduced to be nylon fiber was only very slightly affected. On nylon fibers you get a little

bit of melting because the melting point of the nylon is only round about 100 degrees, say, and it had been very slightly affected. So that indicated to me that no -- there's no great extent of flame beyond about 5 Crosscut.
Q. All right. You --
A. But I must make the point that that's based on two samples at that point. Normally we would have more samples around that area if possible.
Q. Let me come at it this way with you, you did the same thing with each of the coal dust samples, determining which ones were coke or what percentage were coke.
A. Yes.
Q. And I take it when we see in your Table 1, percentage coke up into the 70s, 60s, even as high as the 50 range --
A. Yeah.
Q. -- percentage, does that indicate to you that flame has been in that area?
A. Oh, yes.
Q. Yeah. So that any time we see any significant percentage of coked material, that would indicate flame?
A. Yeah.
Q. All right. Taking all of the samples in total and having looked at them as you have, and we can look at the

tables ourselves, what -- let me ask you this, what is your opinion as to what portions of the mine, the main mine tunnels, Nos. 1 and 2, were exposed to the flame at the time of the explosion?

A. Well, in the number two return roadway, there was indication that flame had gone certainly up to -- I think it was No. 2 Crosscut.

Q. Yes?

A. Yes, I'll just check that point. And that in the -- no, No. 1 Crosscut, that was the furthest sampling point, those indicated the passage of flame. So that's in the No. 2 return --

Q. So that was right up almost to the portals --

A. Right up to the portal.

Q. -- and maybe to the portals?

A. Yeah. That was the furthest sample that I had been supplied with, so --

COMMISSIONER No. 2 return?

A. In No. 2 return. So -- but definitely up to that point.

MR. MERRICK So that would corroborate and be corroborated by any witnesses' statements that we may hear that they actually saw flame shooting out of the portal?

A. Yes.

Q. All right.
A. That would be right, yes. Yes, and in No. 1 intake roadway I deduced that the, from the samples that were taken, that the flame or the effects of the heating from the flame had probably filled most of the roadway in the region between No. 8 and 9 Crosscuts and up to about 175 feet inbye of No. 10 Crosscut, which was as far as I examined. And just based on two samples, Nos. 25 and 41, the flame or hot products were greatly reduced, I had deduced, in the region about 100 feet outbye at No. 8 Crosscut. And by the time you got up to No. 5 Crosscut, that's where the nylon fiber showed the very slight sign of heating, the effects of flame were negligible at that point.
COMMISSIONER So from about here out [indicating on chart] there was few signs of burning then on the --
A. On the intake.
COMMISSIONER -- on the intake, yeah.
A. Yes.
COMMISSIONER Okay.
MR. MERRICK When you say that you only found signs of burning that short distance inbye on No. 1, you're not suggesting that it stopped there; that was just the limit of your investigation?
A. That was the limit of the examination, yeah.

Q. Okay. And how about in No. 2, indications -- what degree of indications that flame would have gone down No. 2? You say that you got indications of flame as far out as No.l Crosscut in No. 2.

A. Yes. I don't think I -- what I've got here --

Q. Your furtherest -- your deepest sample, the most inbye sample, I guess, on No. 2 would have been -- the one that you were able to read was Sample No. 2. But, again, I take it that that was purely because the --

A. Yes, it was limited by the samples we could obtain in that area.

Q. Okay. Let me ask you this, if that -- your opinion is that flame travelled that far out in an indeterminate distance inbye on both mains, what is your opinion as to whether at that point, over the areas of the mine that you were able to examine or take samples, that coal dust was involved?

A. In my opinion that by that time it had developed into a coal dust explosion.

Q. And what do you base that on?

A. Because the flame had extended these great distances and, in my opinion, it couldn't be accounted for by a methane explosion, because you would have had to have great length of roadway fouled by a methane-air mixture. But if you had methane coming out of the Southwest area, because of the greatly increased ventilation flow in the main roadway, particularly the No. 2 conveyor road, you would have diluted that gas probably below the flammable limit. That's assuming that even if it got to that point.

Q. So that you conclude that because of the extent of the area covered by the flame --

A. Yeah.

Q. -- there must have been something more than methane?

A. Yes.

Q. And to what extent is your opinion corroborated by your observations of physical damage?

A. Yes. Well, the physical damage in what I observed could have been caused by a methane-air explosion alone. I couldn't say that was definite evidence of a coal dust explosion in that area. But the evidence, hearsay evidence, provided by draegermen and the -- after the explosion, of the extent of damage in the Northeast -- no, Northwest and Southeast Mains, that's down at the bottom end there, was consistent with a coal dust explosion travelling down the return and developing in speed. And the severe burning of the men in the D Road there was consistent with a prolonged period of burning consistent with a cloud of coal dust burning. And the extreme damage reported was consistent with the dust explosion gathering pace as it went down the incline.

Q. To what extent did you draw any support from your observations of that burned duct tubing that you described to us where just the wire was left?

A. Yes, I had -- we had in the investigation of the explosion at Golborne Colliery in 1979 there was similar type ducting. I couldn't say that it was exactly the same ducting, but similar type electrical ducting involved in that explosion which was completely burned out. Again, it was ducting that wasn't in use, had been left in the roadway. And we suspected that in that particular explosion, the pattern of the explosion, that it had started off with a rich methane air mixture. When I say "rich," I mean in the -- towards the upper limit, maybe about 13 percent methane with air. A flame had developed in a mixture of that type and had moved down a roadway. But subsequently that gas had been cleared by the ventilation and had left what we presumed was burning material possibly in the roof of the roadway.

And the second stage of a two -- there were two stages in the explosion. The second stage of the explosion was that the gas moving into this roadway from a long entry had been diluted to somewhere in the 9 percent region and that you -- that when this gas met the burning material left, there was a much more violent explosion which went either way.

But to get to the point, the ducting was burned out and I conducted some experiments on this ducting by subjecting it to flame in a six percent, a nine percent and a 13 percent methane air mixture. And only in the 13 percent mixture did the complete burning of the ducting material take place which indicated -- was a kind of proof in that particular investigation that this slow burning, rich body of methane had actually burned this ducting and had gotten down to this particular part of the roadway. And so tying that observation into the piece of ducting that I saw near 10 Crosscut in the conveyor return, that suggested to me that if the materials were similar, which I thought they were, that heavy burning had occurred there, and that that wouldn't have been accounted for by a fast-moving methane air flame which would cause the damage of the type that I saw. If the burning had been done by methane-air burning, it would have been done by a rich methane air mixture which wouldn't have created the violence and damage that was apparent in that area.

Q. Was also in that area?

A. Yes.

Q. One last question on this topic. Is it your opinion that by the time the -- assuming the explosion came out of the Southwest district, is it your opinion that by the time that it came out and hit the mains at the 9 and 10 Crosscut, that it was coal dust explosion at that point?

A. Yes.

Q. All right. That's the end of that point, Mr. Commissioner.

COMMISSIONER All right. We'll recess an hour, back at 1:30 so we can adjourn at four. Okay? Thank you.

INQUIRY RECESSED (TIME: 12:34 p.m.)

INQUIRY RESUMED (TIME: 1:31 p.m.)

COMMISSIONER Mr. Merrick?

MR. MERRICK Now, Mr. Brookes, you have provided us with your opinion as to over what areas of the mine flame travelled, what areas of the mine that you were able to examine that flame travelled. You've also given us your opinion as to whether at those portions of the mine the explosion was at that point involving coal dust. Have you looked as well at other information and evidence relating to the explosion?

A. Yes, I've looked at reports provided by the draegermen in the post-explosion investigation and also in the examination made by the RCMP in September, 1992.

Q. All right, and the reports of the draegermen, that would be the interview statements that were given and are in the possession of the Inquiry.

A. Yes.
Q. Of the draegermen involved in the rescue.
A. Yes, sir.
Q. And the RCMP are the RCMP records that have been recently made available to the Inquiry and that were provided to you.
A. Yes.
Q. Did you look at other reports as well?
A. I looked at some of the other consultants reports.
Q. What about the autopsy reports?
A. Pardon?
Q. What about the autopsy or chief medical examiner's reports?
A. Yes, I've seen copies of those, yes.
Q. All right. Based on all of that information, in addition to the evidence that you yourself gathered or had gathered and analyzed, do you feel that you are able to develop an opinion as to how this explosion actually initiated and then propagated through the mine?
A. Yes, I can make an assumption about the actual development of the flame and some assumptions about the possible source of ignition, but I wouldn't be able to say definitely that one particular source of ignition was the cause of the explosion.
Q. All right. What I would ask you to give us is your

opinion as to how you do believe the explosion initiated and occurred to the extent that you can draw conclusions or form opinions.

A.   Yes. I think the most significant part of the information that I read, apart from the general directions of blast, those were, if I may deal with those first, the evidence within the Southwest district, the blast was in the direction of the No. 1 intake roadway and the No. 2 conveyor return. That was based on the statements by three of the people who were in the area, presumably draegermen, after the explosion. And I give references to those people at the bottom of the page of my report.

Q.   This is page 20?

A.   I'm referring now to page 20.

Q.   Yes, and I should indicate that the portions of the transcripts of those interviews that are referred to there are attached in Exhibit 44 which is a booklet that goes with Mr. Brookes' report. I won't get you to go through them now with me. We'll just identify that they were the sources, unless you want to point out anything particular.

A.   That was the first thing. The blast appeared to be from the Southwest district towards the No. 1 intake and the No. 2 conveyor return. The No. 2 conveyor return outbye of No. 9 Crosscut, it was in the outbye direction as witnessed by the ejection of a steel door at the portal. That was information that was given to me, and I've seen a photograph which maybe shows that door, but I can't say I actually saw that door.

In the No. 2 conveyor return, inbye of No. 10 Crosscut, it was in the inbye direction, although there was some contradictory evidence in the region just outbye of No. 11 Crosscut.

So we've got indications of blast coming out of the Southwest this way, up the return roadway to the portal that way, also up the intake road to the portal, witnessed by the damage to the cladding at the portal. And then the evidence of the blast direction inbye of 10 Crosscut in No. 2 conveyor return. For that, I give accord to Mr. Cheverie in a statement published on the 7th of August, 1992 when in the North Main going down these roadways, it was generally in the inbye direction and the references to those, Mr. Hudson, Mr. Muise, Hillier, MacNeil.

So that gives me the general picture that it started somewhere in this Southwest working area and came down these roadways, divided when it hit the main returns, travelled outbye to the portals and inbye to the North Mains, northwest and southeast workings.

I think the most significant information that I was given, and it's also covered by the medical examiner's, chief medical examiner's report, is that the men in the SW 1-2 heading, the six men employed there at the position of the continuous miner and the roof bolter in the left-hand roadway, had obviously had some warning that something was happening because they had had time to move down that roadway in an outbye direction and were obviously trying to don their self-rescuers while doing this. So this is apparent that something had warned them and they had time to move. The actual distance at which they moved were given in some of the draegermen's statements, and also in a plan that I saw provided by the RCMP. Naturally, under the conditions on which they were operating immediately after the explosion, there were some discrepancies in the kind of quotations of distance or estimates of distance that those men had moved, but they varied from 50 feet up to 220 feet. And the references I give to those estimates of distance are also given on my report at page 21.

It's difficult to say from that how long it would take them to actually move those distances under the conditions that prevailed or what had caused them to try and get out of that area. I made a rough estimate myself of struggling along trying to get out a self-rescuer and how long it would take to, say, cover about 100 feet and I thought the order of time would be 10 seconds, which it doesn't sound very much but it's quite a considerable time, if you think about 10 seconds.

So my conclusion from that was that they had seen some or probably seen some sort of flame develop and it was probably in a methane roof layer of the type that we've been talking about earlier, and it may have started off burning slowly and they saw a flickering or flame moving about in that general region, saw something was happening, and decided to get away as quickly as possible. But the flame developed and may have actually passed over them while they were attempting to escape.

Evidence that this may have happened is that these men, the six men in that SW 2-1 heading there suffered superficial burns which suggest that they were heated from above to the face and head and they were overcome by carbon monoxide poisoning and must have been knocked out fairly quickly by this, by breathing in this gas.

The carbon monoxide is produced in the reaction when methane burns. If you don't get complete combustion; in fact, if there isn't sufficient oxygen to burn the whole of the methane, if you have percentages of methane air below nine and a half percent, anything from that down to the low limit concentration of five percent, you usually get complete reaction so that the whole of the methane is burned and the product then of the methane combining with the oxygen is carbon dioxide plus water. Those are the products of the combustion.

But if the mixture is richer than the nine and a half percent, as you would probably get in a layer, particularly if it was a rich mixture and burning slowly, without complete combustion taking place, you would get this carbon monoxide produced which is, of course, a deadly poisonous gas. And this is what --

So my picture of these men trying to get away, they're getting part way down the roadway, but then the flame developed in this layer and the turbulence caused by the initial flame starts to mix the gas so that the mixture of gas comes lower in the roadway, starts to burn more quickly and, indeed, may have passed over them as they made their way down the road. The products of the combustion, the carbon monoxide then hit them. They breathe that in and fell on the spot.

In this scenario, the flame would develop moving faster as it came down to the open end of the entry. If there were cavities present, it may have produced turbulence which would bring gas out of those cavities because of the rising heat and combustion and convection and so that you start to get a rolling flame, and the progression of that flame would be faster, and by the time it got down to the intersection and into the SW 1-A and SW 2-B Roads where the conveyors were situated, or perhaps at the intersection, there would be enough gas mix so that the whole roadway might be filled with a flammable mixture at this point.

And then you would get a more violent explosion down these two roadways and that violence would continue, perhaps picking up any gas from other cavities or any gas that was in those roadways in the form of a layer mixing it and increasing in violence until it reached the C-1 or B Road there, particularly the B Road where the conveyor is situated.

And presumably somewhere along the conveyor road, it's difficult to say exactly where, but it would start to pick up the coal dust and develop into a coal dust explosion.

By this time, the supply of methane may have run out so that by the time it reached the main roadway, and by this time it was developing considerable violence, it would be mainly probably a coal dust explosion which destroyed the crossing point at the No. 9 Crosscut.

And from there, the flame would go both ways down the conveyor road towards the North Mains and out this way to the portals.

At the same time, the flame, parallel flame, would be travelling down the SW 2-A Road into the C-1 Road here. It's difficult to say how much flame would be involved or violence there, but if it was mainly in the B road, these crosscuts would be blown out and the shock wave would travel down the C-1 Road into the 10 Crosscut so that you get two explosion flames or two pressure waves at least, a flame in one and a pressure wave in the other, which meet in these roadways and transfer in each direction. There would be some turbulence and mixing at this point where the two waves reached the return roadway there.

Then, in my estimation, the explosion flame having reached the main conveyor road here would be self feeding by coal dust in both the outbye and inbye directions, and the coal dust explosion would travel down these roads with a fairly long run-up time increasing in velocity and increasing in pressure until it finally hit these headings here. And the people in these headings would have probably had no warning of or very little warning of what was going to happen to them as witnessed by some of the statements in which they were still holding roof bolts and had obviously been taken completely by surprise as opposed to the men in the Southwest here.

There would be considerable after burning of the coal dust particles which would cause severe burning to the men as opposed to just superficial burns of the men here. And this also is evidence to me that a coal dust explosion, indeed, had taken place and transferred right down into these workings of the Northwest and into the Southeast here causing the great deal of damage that was reported to have occurred.

To go back to the SW 2-1 heading, the possible source of ignition -- Do you wish me to continue with that, Mr. Merrick?

Q. Yes, please.

A. There would possibly be the continuous miner and there is evidence that this seam, the Foord seam, does contain iron pyrites. There's a band of 12 centimetres shown in the general geological plan of the seam, but that doesn't necessarily mean it was there. I'm saying it might have been there. One cannot be sure that it was there but that would, if it was there and the picks were blunt as we've discussed already, that may have been a possible source of ignition.

There was a roof bolter in the left-hand heading here, but the evidence from the rescue teams afterwards and the RCMP report was that no steel drills were fitted and it appeared that those bolters were not working. But, as I pointed out in my report, it doesn't rule out a passible electrical source of ignition, not that I know that anything was happening in that way.

The other possibility is the bolter in the continuation of the SW 2-B Road here. But, again, the report was that no drills were actually in the machine, and it didn't appear that actual drilling was taking place. In that situation, if there were drilling, the possible source is another frictional ignition, but I think that that situation can be ruled out by the fact that no drills were fitted in the bolting machine. But, again, it doesn't rule out that some kind of electrical work was going on which could have been the source of ignition.

The men in that particular heading, the B Road, didn't have the warning that the men in this road apparently had. There were five men found in this roadway. There was a report I saw that one of the men, the particular one right at the face at the bolting machine had perhaps tried to make an attempt to put his self-rescuer on. I believe a self-rescuer was found on the floor near there and he may have had a little more warning than the men who were found further out. Two of these men, I believe, were from a boom truck which was situated at the junction there.

In fact, just to recoup a moment, back to the SW 2-1 roadway, and the supposition that there may have been sparking at the continuous miner. There were reports previous to the explosion of sparks being seen when the cut picks were working at the face. There were several reports I saw, two of them I've listed in my report. MacNeil, for example, states that he saw sparks being generated by the cutter picks from the face and which he attributed to dull picks and a vein of pyrites in the seam. That was obviously at some earlier stage in the mining process before the explosion. But it's interesting that he attributed it to dull picks, which as I said earlier in my evidence, that the experiments that were done to ignite methane air by striking iron pyrites were done with dull, blunt picks.

And Robinson also saw sparks, he says, from stone and pyrites in the seam. So there is evidence that on previous occasions there had been sparking seen and that there was pyrites in the seam. But no one, to my knowledge, had ever seen an ignition of gas, I must point that out.

Quite often, if I can just digress a moment from the actual description of the explosion while I think about this, in United Kingdom mines, certainly around about 1980 and earlier, I'm not talking about their present situation, but there would be anything of the order of 20 to 30 ignitions of gas on the coal face while machines were in use. These were mainly due to striking the quartzitic rock where we've talked about, but these were reported ignitions and they didn't amount to very much, fortunately. There would be a little flash and a small flame of a few meters long. But, nevertheless, these ignitions had to be reported and we were sent the details. But, as far as I'm aware, no ignition of gas was reported at Westray.

Q. I take it, Mr. Brookes, that it is not likely that sparks themselves, the sparks that you would see, might be the ignition of methane if it's in the area. But if you have got pyrites and dull picks, you may be getting the other ignition mechanism that you described this morning.

A. That's right, yes.

Q. All right, thank you. I mentioned the miner, the continuous miner, I mentioned the bolting machines as possible sources.

Now the other possible source of ignition was the boom truck situated at the intersection of these two roadways. It was parked across the intersection and initially when I, three years ago when I was writing my report, I didn't consider that as a possible source. It's only by the light of later information that the team that went in with the police in September of '95 -- '92, sorry, September of '92, the evidence was that the boom truck might have been left with the engine running. It was described by Mr. Bossert's report, which I've referenced, as a non-flameproof diesel engine or diesel-powered machine. So that is another possible source of ignition.

The mechanism to cause an explosion by the boom truck would be somewhat different to the type of explosion that I've outlined for one emanating at the continuous miner. In this case, a layer of gas that Dr. McPherson talked about coming around the roadway there and reaching -- or coming up this roadway here and reaching this junction, could have been mixed by turbulence due to the presence of the boom truck at that place. But if the engine was running, to the heat generated from the machine, which the heat would rise and produce convection currents so that you'd get some circulation and there is the possibility that under those conditions that gas could be brought out of the layer and down to a point of ignition on the boom truck. Mr. Bossert, in his report, outlines various possible sources of ignition from that boom truck and included in those is sparking from alternator brushes, hot manifold or exhaust pipe or catalytic converter or delayed ignition in the exhaust system or methane being drawn into the inlet of the machine and a backfire occurring which would put flame out of the exhaust or the intake. So that these are the possible sources of ignition that he outlined.

COMMISSIONER Perhaps just to clarify one point here for me, if you would, Mr. Brookes. There's been a lot of talk about the boom truck. You might not be the right person to ask this of, but I will anyway and please defer if you feel you should, but this boom truck, it was just a run-of-the-mill diesel truck with no particular modification for underground operation. Am I correct on that?

A. Yes.

COMMISSIONER So you could have seen the same thing at the intersection of some street somewhere.

A. Yes.

COMMISSIONER Okay. Thank you.

MR. MERRICK Have you ever seen that kind of thing before in a mine in England where they would drive a diesel-powered truck up close to a face like that with no flame or safety safeguards?

A. No, I wouldn't have thought. I mean, my experience of mining is really in investigations, but certainly within those investigations, I never saw anything like that. And I think it very unlikely that anything like

that would be allowed in a British mine.
Q. Recognizing that your background is investigations and not mining, what if you had happened to be walking up that roadway in Westray knowing that it was a working mine and knowing that there was a working face just up there and you saw a diesel truck sitting in that intersection running? What would you do?
A. Well, yes, I wouldn't be very happy with that situation, I'm sure.
Q. Okay. Just while we're on the point of the diesel truck, one of the possible sources of ignition on that truck was the hot exhaust.
A. Yes.
Q. I'm talking here about the exhaust itself, not necessarily methane being drawn in through the ignition system and then burned through the exhaust?
A. Well, and both things according to Mr. Bossert.
Q. I know. But what's your opinion on whether the exhaust itself would be sufficient to ignite methane?
A. Well, that is a difficult question for me to answer because I have no direct experience of --
Q. All right.
A. But I might just add to that that if the actual exhaust -- we're talking about the metal of the exhaust, presumably, it would have to be glowing red -- glowing

red hot to -- you need that sort of temperature of surface to ignite the methane, temperature of about 537 degrees at least. But, again, I'm no expert on diesel equipment, but from what I've gathered is that if you draw methane into the inlet of such a machine that you do get a much hotter product within the exhaust system.

Q. All right. All right, continue with your --

A. Yeah.

Q. -- explanation of your --

A. So this is -- it must be included as a possible source of ignition. If that happened, the path of the explosion would be somewhat different if it were ignited there as opposed to up there because in this case the flame, if there was a layer in the SW 2-1 roadway, the flame would be running into the entry and not out, as opposed to an ignition at the top of the entry.

And this raises a question in my mind as to what would be the reaction of the men in that heading. Presumably, if the ignition occurred down there and they did get some warning of it, those men would fear flame coming towards them. And maybe -- their only one way out though is to run towards the outlet, but that would be towards the flame. And it's questionable in my mind anyway what you would actually do. I think they're more likely, if they saw a flame at the head of the entry near the machine, they're more likely to be running to get away from it. But that is only my opinion.

Again, if we leave that for a moment, if we go back to the ignition supposition that it occurred at the mine or at the top of the heading, I've already said -- explained how that would develop down the roadways by mixing gas from layers and from cavities and gradually producing a mixture in the roadway and progressing outbye towards the main road. Well, if it occurred at the junction, something similar -- if it was in a layer and the flame licked back from the boom truck to the layer and a layer down the SW 2-B Road was ignited, the same sort of conditions would prevail that it would gradually develop into a full-scale methane explosion and then follow the same course as before, developing into a coal dust explosion at some later stage before it got to the main roadways. So the only significant difference there would be, between those two sources, would be the direction of travel of flame in the actual SW 2-1 entry, but from there on I think the pattern would be fairly similar.

When I first thought about this, I thought if the -- the big thing, the gas from the SW 2-1 entry, the mixing had created the mixture at the junction and that was where the main body of gas was ignited, that would be the

-- what we used to call the "quiet zone," and I think Dr. McPherson explained this. The center of the explosion is quite often the place where you will get the least damage because the explosion is travelling away from that area. And, indeed, there seemed to be little damage to the boom truck or little damage in that area.

Q. Indeed, if we look again at that photograph that we were looking at earlier through the piece of the heading with the boom truck in it -- let me just see if I can call it up. Yeah, it's Photograph 25 from Exhibit 59. That piece of vent piping that's slung in the low side of that roof, it obviously -- I assume if there was much violence involved in that area, it would have disturbed, dislodged -- whether it would have burned or not, but it probably would have knocked that tubing down.

A. Sorry?

Q. Looking at that tubing in that photograph --

A. Yes.

Q. -- I assume that because it's still there and hasn't been knocked down, that it would indicate that nothing of much violence occurred right up in there?

A. Yes. Yes, that's correct.

Q. And we also notice the steel mesh that's been put around the walls, et cetera, not much sign of damage in there?

A. No.

Q. Indicating, picking up on your last point, that that heading must have been somewhere close to the place where the explosion initiated?

A. Yes, that seems likely. Although I must say that if a flame had travelled in towards the top of that heading, you -- in that case you wouldn't have expected much violence produced by a burning layer going towards the closed end of that heading.

Q. Just a burning layer?

A. Yeah.

Q. But if the explosion had occurred any distance from that Southwest heading, and I'm thinking if for any reason there were a point of ignition further down the flame then would start to run up there and into that heading, it would be gathering force?

A. Yes.

Q. And that if you get your point of ignition too far away from that heading, you're going to get violence up in that heading?

A. Yes. Yes.

Q. So that that tells us that we can't go too far from the area of relatively undisturbed heading?

A. No.

Q. Including the junction here?

A. No.
Q. All right, thank you.
A. There is a point that, having -- while we're looking at that photograph, there is some conjecture as to why that piece of ducting up there wasn't burned. And I've already said that there's probably a small flame at the base of the layer that was only burning slowly and not mixing fully with the total gas available there. But another point is that if you look at that photograph and it --
COMMISSIONER 25?
A. -- at 25, yes, and also -- well, it's also -- also a diagram is shown in Mr. Farrell's report, Sketch 5.
MR. MERRICK This is -- you're now looking in Exhibit --
A. Exhibit --
Q. -- 44.
A. -- 44, yes.
Q. What page up in your corner?
A. Page 0 -- it's page 0-100.
Q. Just let me catch up to you here. Yes?
A. You see that the roof of that roadway is inclined so that the left-hand side is much higher than the right-hand side, so that if a layer formed there, the thinnish part of the layer would be at the side where the ducting

is, and that may be another point as to why the ducting didn't burn because you've got little -- only a thin layer in that position.

Q. All right. Is there anything else that you want to tell us?

A. There's just one point. On page 24 and I'm suggesting that the explosion would have progressed -- propagated preferentially possibly along the B conveyor road. The -- I put that the conveyor passes through a belt seal in the B Road just inbye of the SW 1-2 Crosscut. I think that's somewhere there.

Q. Yes.

A. I've actually found that it was originally on a plan I saw described as a belt seal but it is, in fact, plywood covered opening there, but it doesn't alter the basis of what I've said, that that obstruction would result in increased turbulence. It's not a complete seal. It's a space where the belt can pass through, but it's put there to stop too much short circuiting of the air in the crosscut so that the turbulence there would perhaps be responsible for raising coal dust into the air, which would add to the general initiation or propagation of the coal dust explosion.

Q. All right.

COMMISSIONER May I just ask a brief question here, Mr.

Brookes? You've been -- this isn't by way of criticism, but you have been speaking on this explosion now for about a half an hour. Can you put it in context from this point, if we accept the fact that the point of ignition was up in here, how long would it have taken or can you hazard a guess how long it would have taken for that explosion to get up to the portals?

A.   A matter of seconds, I would say.

COMMISSIONER   That's what I -- yeah.

A.   It raises a point which I could make at this stage. The crosscuts, the concrete crosscuts, between the main roadways were blown out as we've already said, and they don't need a great deal of pressure, it's the static pressure produced by the explosion that pushes those out, but with some violence. And the -- an estimate of that sort of pressure might be around a third of an atmosphere. But if we assume that it was one atmosphere, the over pressure was, say, one atmosphere, which would throw the concrete or break it up and throw it violently against the left-hand side of the No. 1 intake, that sort of pressure correlates with a flame speed of about 150 meters per second which probably people will appreciate if I say getting on for 340 miles an hour. So that's the speed that flame would be travelling out of the mine.

COMMISSIONER   So the --

A. So --
COMMISSIONER So the entire event would have been over in less than 10 seconds or so?
A. Yes, I think that's quite --
COMMISSIONER Okay.
A. I'm just thinking there --
COMMISSIONER Yeah.
A. -- I said 150 meters per second. That was only a guesstimate, really, of what --
COMMISSIONER Sure.
A. -- it might have been. It might have been faster than that, but that would take, say, about four seconds from the region of 9 Crosscut to reach the portal.
COMMISSIONER Yeah, okay.
A. So the -- yes, the estimate of 10 seconds after it had developed --
COMMISSIONER Yeah.
A. -- of the -- It is perhaps of the right order.
COMMISSIONER Thank you.
A. It may have been even faster going down into the --
COMMISSIONER Down in the North, eh?
A. -- North Mains and probably was.
COMMISSIONER Yeah.
A. I mean, speed --
MR. MERRICK That would be that run-out principle that

you were talking about?
A. Yes. Speed is of, again, it's just a pure speculation. I have no evidence for this, but from experimental explosions, you can get speeds of, say, 1,000 meters per second in a coal dust explosion, in a burning-type explosion so that, you know, that's the sort of 1000 meters --
Q. All right.
A. -- probably less than a second to get to that.
Q. Of the various possible actual sources of ignition that you've identified, I take it, you, in your own mind, are satisfied that you can pinpoint the most likely one?
A. Yes. If I were to put them in order of things --
Q. Yes.
A. -- I would put the continuous miner first and the bolter second -- the boom truck second and the bolter third.
Q. All right. One question that came out of your answers, you said to us that carbon monoxide, that if methane is burned at a low concentration of about nine percent down to five, that it is usually carbon dioxide --
A. Yes.
Q. -- and water that's produced?
A. Yes.

Q. Carbon monoxide is not produced --
A. No.
Q. -- when it's burning in that range?
A. No.
Q. And that if it's burned at a concentration from nine percent up to 15 percent, that's when carbon monoxide is usually formed?
A. Yes.
Q. Something I hadn't known but taking that to be case then, if the men up in the Southwest district died of carbon monoxide, then the methane that was burning in that area must have been at those higher concentrations?
A. Yes. That seems to be likely, yes.
Q. Again, I suppose, tending to support the mechanism of a fairly concentrated layer of methane?
A. Yes.
Q. All right. Thank you. Okay, let me bring you to one other question. I've just got a couple of more topics for you here quickly. You've investigated a number of disasters. In this particular one we may never be able to say with certainty whether it was the continuous miner or the bolter or whatever.
A. Yeah.
Q. But in light of all the evidence you know of the Westray disaster and the evidence that we now have as to

the various conditions that were leading up to the disaster, what do you say as to how significant it is that we may never be able to pinpoint the exact location?
A.   Well, I don't think -- I mean, it's nice to be able to answer the question and, I mean, from the investigator's point of view and being able to say that this was the point where it started and to explain it fully which was always our aim, but I think in this case it's not a great deal of significance to actually know what the igniting source was. I think the point is that the igniting sources were there available and the fuel was there, was available. And those two produced a deadly mixture. You've got to have the two of them to produce the explosion.
Q.   I suppose then that the significant features here are that, (a) there were in fact ignition sources available and fuel available. And what is now significant is not necessarily pinpointing the exact one but what were the conditions that led to that?
A.   Yes, I would agree with that. Yes.
Q.   All right. I would like to ask you about stone barriers for a moment because English mines have had considerable experience with them. They've been required by law since about the early '60s?
A.   Yes, they came into use primarily to protect

conveyor roads which were difficult to protect by stone dusting alone, and they have been legally required in the U.K. mines since the early '60s.

Q. In your experience and based on what you know, how effective would you say that the use, widespread use of stone barriers in England, has been in minimizing the effects of ignitions that have occurred?

A. Well, in actual ignitions they -- they have been limited because there haven't been any coal dust explosions except one that I personally know of. And in that particular explosion, it was evident from our examination that coal dust had begun to be involved in the explosion and it -- the pressure wave struck a barrier of stone dust. And the flame was stopped almost immediately. Within 20 feet of that barrier, the explosion was killed, stopped. And the barrier was smashed, the wood was smashed and everything down the roadway. The shock wave went on and gradually attenuated and petered out. But that was a successful operation of a barrier which prevented a coal dust explosion developing.

Q. Which explosion was this?

A. This was way back in 1962, Mainsforth Colliery.

Q. But this was then a graphic example -- so you say you had evidence that prior to hitting the barrier, it

was not only methane but coal dust --
A. Yes.
Q. -- in the explosion?
A. Yes.
Q. Hits the barrier and within that distance came to -- that was the end of it?
A. Yes.
Q. What do you say as to whether stone dust barriers are practical in a room-and-pillar operation?
A. I would imagine they're difficult to operate in an actual room-and-pillar system. But not impossible. The main roadways leading to the room-and-pillar developments could be protected by the barriers. The main problems I think are the -- following the development and quite labour intensive, I suppose, erecting barriers and trying to keep up with the development of the face. But there are other possibilities such as water barriers which are now superseding stone dust barriers. And these operate on the same kind of principle that the shock wave from the explosion tips the barrier, but instead of putting stone dust into the air, it puts water into the air. And these are easier to maintain, easier to erect. You've got light plastic polystyrene tanks which are easily smashed by an explosion, pressure wave or shock wave and the water from them is dispersed into the air and acts as

a heat sink the same way as the stone dust acts.
Q. And I suppose that they're more maneuverable so that you can actually --
A. Yes.
Q. -- move them around in a room-and-pillar --
A. Yes, you're not carrying lots of stone dust baggage down the mine. You're -- you can get water from the main system.
Q. And when you say protecting the main areas, in your view then they could have been practically used here at the entrance to the Southwest district in the C-1 and B Roads?
A. Yes. I must say that I have no practical experience or -- nor a deep knowledge of the position of stone dust barriers except to say in general that I know they're usually used to protect areas near the working face. But they're also used to protect areas round the junction where a road, say, from the Southwest area there, round these junctions will be to protect it. You have one in that C-1 Road, say, or the B Road there and on other side of the junction.
Q. Oh, yes. So you put them right around the junction like --
A. Yeah.
Q. I follow you.

A. Yeah.
Q. Let me ask you for a moment about the inspectorate in England.
A. Yeah.
Q. Your mines are inspected by regulatory officials?
A. Yes.
Q. And I would assume generally in the same type of jurisdictional review that we have here in Nova Scotia, in that they are to be inspected as to the safety of operation, et cetera?
A. Yes.
Q. The inspectorate is part of the government?
A. Yes. In fact, the -- I think -- well, maybe we didn't mention but the -- I worked, as I said, at the Safety in Mines Research Establishment which became part of the Health and Safety Executive in 1975 and was renamed the Explosion and Flame Laboratory of the Health and Safety Executive. And that, after 1975, we became the Safety Research Establishment for the whole of industry, not just mining.
But when that body was set up, the Health and Safety Executive, all the inspectors, including the mine inspectors, the factory inspectors, explosive inspectors, pollution inspectors, all came within that one group so that the mines inspectors were in the same Health and

Safety Executive as the Research Lab and, again, they could call on our help.

Q. What qualifications would you need to become a mines inspector?

A. I believe they have to have been a manager or undermanager of a mine for at least two years.

Q. Indeed. So they would have had to have the mining certification --

A. Yes.

Q. -- that would have been required --

A. Yes.

Q. -- for a manager or undermanager?

A. Yes.

Q. Underground manager?

A. Yes.

Q. And they would have had to have also had the period of time practical experience?

A. Yes.

Q. That's a pretty well qualified mine inspector.

A. Yeah, they were very highly qualified people and very highly paid people.

Q. Is that right? Well, I guess one goes with the other. And there would be various levels of inspectors, I take it?

A. Yes, they would be recruited as -- with the title

Mines Inspector; that could progress to "Senior District Inspector and Principal Inspector and Deputy Chief and Chief.
Q. But at your lowest level you had to have that minimum certification --
A. Yes.
Q. -- and experience?
A. Yes.
COMMISSIONER Can I carry that one point further, Mr. Merrick? And I don't know whether I'm on the right track or not, but in the U.K. would the majority of your mine managers and undermanagers have been mining engineers?
A. Oh, yeah. Well, I think they all would.
COMMISSIONER Okay. So to extend further then, not only would a -- well, not only but the person who is the mine inspector would have to be a mine manager or an undermanager --
A. Yes.
COMMISSIONER -- who would also have had to have been, to get to that position, would have to qualify as professional mining engineer?
A. Yes, indeed.
COMMISSIONER Yeah, okay.
A. And, in fact, if I may add that there were a lot of people in the industry who had those qualifications who,

because of the limited number of opportunities, would not be perhaps managers or --

COMMISSIONER Yeah.

A. -- undermanagers.

COMMISSIONER I see. Okay, thank you.

MR. MERRICK In the investigation of a disaster that would occur there, just give me a brief overview, if you will, as to the role of the inspectorate in becoming involved in the investigation?

A. Yeah. The inspector would really take charge of the mine, be in charge of the investigation under the jurisdiction of the chief inspector and that's where we came into the picture. We would be -- if we were required to help, we would be called in by the chief inspector and would give scientific help to the inspectors. But they really took charge of the mine from the moment the disaster occurred.

Q. So the rescue efforts, the investigation, would be under their ultimate responsibility --

A. Yes.

Q. -- and control?

A. Yes.

Q. They would have jurisdiction as well, I assume, to cease the mine or to impound --

A. Yes.

Q. -- pieces of evidence --
A. That's correct, yes.
Q. -- or equipment?
A. Yes.
Q. So that I'm just trying to think of what would happen in a British mine disaster in the moments afterwards. The inspector would arrive, and there would be no doubt about it, that's the person that would have the ultimate responsibility?
A. Yes.
Q. So people wouldn't be walking around sort of informally doing things?
A. No.
Q. Okay. Those are all the questions I have for you, Mr. Brookes.
COMMISSIONER Thank you. Mr. Roberts?

EXAMINATION BY MR. ROBERTS

Q. Just one question, Mr. Brookes. Employees working at the surface of the mine at the time of the explosion reported hearing two distinct percussive sounds, a boom followed by a louder boom virtually instantaneously but quite distinct. I'm wondering how that fits with your scenario of the propagation of the explosion?
A. Yes, it's a difficult one for me to answer. The second sound may have been from some sort of reflection

or -- of a shock wave hitting some object and coming out at a later stage than the first blast. But, you know, that's just an opinion.

MR. ROBERTS Thank you.

COMMISSIONER Mr. Hebert?

EXAMINATION BY MR. HEBERT

MR. HEBERT With respect to the explosion within the Southwest section and the possible centre of the explosion, I'm having a little bit of difficulty understanding, and I appreciate that you didn't do a detailed investigation into that area, and you can only rely on what you've been told and what you've observed through photographs and such. But it strikes me that there's two possibilities, or maybe an infinite number, and that there might have been an initial explosion at the boom truck or perhaps further on down at the intersection of the B Road with the Southwest 2-B road. And I think those were raised by an earlier witness.

A. Sorry, I'm not -- You're saying that is what I suggested?

Q. No, I believe an earlier witness, Mr. McPherson, had suggested that that might have been one of the areas, that the flame could have gone overhead. I'm not talking about the ignition of the methane.

A. No.

Q. This question is based on my understanding that there's a distinction to be made between the ignition of methane and the point where an explosion occurs.
A. Oh, I see, yes. Yes, I get your point, yes.
Q. I take it that's a valid distinction, is it?
A. Yes, it's the sort of point I made that if you get the initial ignition in the layer and that travels down near the roof gradually mixing and getting lower, that the turbulence created by that flame could produce mixture that filled the roadway, and if that mixture was in the flammable range, and say, for the sake of example, might be round about nine percent, which is the most violent or the mixture to give the most violent explosion, that's when you would really get the main bang starting.
Q. Okay. Now I take it that that point is equally difficult to determine based on the information that you have available to you.
A. Yes.
Q. Where that occurred?
A. Yes.
Q. But would it be true that no matter where it occurred, that the shock wave from that would progress in whatever direction was available to it?
A. It would, yes.

Q. All right. Just looking at the rough distances, if you will, if you look at the Southwest 2-B Road where it intersects with the main B Road, if you will, which is the return airway into the Southwest, maybe you can just indicate with your light on the map just to make sure we're at the same point.
MR. MERRICK You may want to use the upper half. It's slightly bigger detail.
MR. HEBERT Okay.
A. It's that one, isn't it?
Q. I think that's the A Road. Southwest 2-B Road would be the one up above it.
A. Oh, that's the B Road, yes.
Q. Now if we keep going back to the intersection of the Main B Road where the light is, if an explosion, a methane explosion, if you will, had taken place there, and it strikes me that that's about the same distance out to the main return or the main intake as it is back into by the boom truck.
A. Yes.
Q. Would you not expect that there would be a similar force applied in that area as a consequence of the explosion as would have occurred at the intersection of the intakes in No. 9 and No. 10 Crosscuts?
A. I'm not sure I grasp your question on that point.

Q. All right, I guess I'm just trying -- We know that there was a great deal of damage, energy, violent energy directed right at the No. 9 and No. 10 Crosscuts.
A. Yes.
Q. Now it strikes me as a lay person that if, in fact, there was a methane explosion which was triggered around where the light is flashing now at the intersection that we described earlier, that there should be an equal force applied back into the Southwest 2 area.
A. Yes.
Q. And whether that would have been as a result of additional coal dust or just the force of the methane itself, it strikes me that there should be a similar level of damage back the same distance away from that centre as at the No. 9 and No. 10 Crosscuts.
A. Yes, I think that's feasible, yes.
Q. So the fact that there isn't the same level of damage back by the boom truck and into the Southwest section, would that somewhat mitigate against accepting that location at the intersection as a possible source of the explosion?
A. Yes, I would think so, yes.
Q. Which would mean that the main area of explosion would have to have occurred back more towards the Southwest.

A. Yes.
Q. Okay. Just a couple more questions, sir. With respect to your investigation, you indicated that when you first arrived to conduct your investigation that you were advised that there were dangers and that you shouldn't enter the mine at all. I'm just interested to know who gave you that advice? Who was advising you of this?
A. If Mr. Merrick will help me with this one, but I think it was probably the -- Was it the Labour Department?
MR. MERRICK I believe, and to just assist the witness, a number of people were advising you against it. There were a group of union members the night before. The Department of Labour was expressing somewhat extreme cautions. In fact, I think they were debating issuing an order and certainly that day we were advised by a number of draegermen, including Mr. Dooley, in rather graphic terms.
MR. BROOKES We were, indeed, yes.
MR. MERRICK Something you remember.
COMMISSIONER We shan't bother getting that into the record.
MR. HEBERT I see, okay. So you had mentioned one danger and I think that was the possibility that there

might have been some pockets of carbon monoxide still present which might be expelled.
A. Yes.
Q. I take it some other dangers might have been roof falls and that sort of thing?
A. Yes.
Q. Those would be the main dangers?
A. Yes.
Q. Now, again just a lay person, can we assume from the fact that there was not a propagation of the explosion through the No. 1 intake beyond what we know to the No. 5 crosscut.
A. No. 5 crosscut, yes.
Q. Was that because there was no coal dust present sufficient to propagate?
A. Yes, that seems to be the implication, that there wasn't enough dust in that roadway to --
Q. Because if there had been enough dust, it would have been propelled or unsettled and taken into the air.
A. Yes.
Q. Okay.
A. Yes, my opinion was that when the crosscuts, the seals were broken by the main explosion coming up the No. 2 roadway, that pressure waves would travel through to the No. 1 return and it would be -- the explosion in that

case would not be so much flame but as a pressure wave which would do the damage to the No. 1 portal cladding sheet.
Q.   Do you know just from your own knowledge of the geology of that area, was that part of the mine in through coal, the entries through coal, or was that through other?
A.   Well, I can't answer that question completely, but I will say that earlier in my evidence, I said I took a piece of lump coal from the surface near No. 9 crosscut. So there was certainly exposed coal in that area.
Q.   Okay. Could that also be another explanation as to why the flame wasn't propagated through that area if, in fact, you didn't have a coal sides or coal bed?
A.   Well, I think the reason probably that it didn't propagate in the No. 1 intake is that you wouldn't get a lot of dust as the air going down that roadway and all the coal is being conveyed out of the No. 2 road. So that you wouldn't expect a great deal of dust in that area.
Q.   Now in terms of the men that were in the Southwest section, I think your report indicates that at least one might have already bitten down on the self-rescuer?
A.   Yes.
Q.   In these circumstances, based on what you know,

would the self-rescuers have provided any protection at all?
A. Doubtful, I think, in this situation. You've got to have enough oxygen as well to breathe with that type of self-rescuer. I think they were really basically designed for incidents where fire started somewhere in the mine and carbon monoxide produced would be travelling around in the ventilation stream. In that situation, it would give someone a period of perhaps half an hour to move out of the area.
Q. So their chances of survival was really nil in your estimation.
A. Yes, I would think so, yes.
Q. There was really nothing that they could have done?
A. No.
Q. Would you have the same opinion if they had ready access to the Oxy-60 self-rescuers, if they were able to --
A. They may have been able to survive with those but, then again, I don't know how they would be affected by the burns that they had suffered.
Q. But it would have provided them with a source of oxygen, a breathable atmosphere.
A. Yes.
Q. Now this is probably an obvious question. I don't

have the speed of sound at my fingertips, but I take it that the blast was travelling faster than the speed of sound?

A. No.

Q. It wouldn't?

A. No. It wouldn't -- The speed of sound increases with the temperature of the medium in which it is travelling. So it might be travelling faster than the speed of sound in the normal atmosphere with ambient temperature, but not above the speed of sound that would prevail in those conditions.

Q. So would the sound be roughly the same, travelling around the same speed or would there be a perceptible difference from a person -- I'm thinking of the people in the North Mains, for example. Would they have heard something first?

A. That could have been a possibility, I imagine, but I think it is very difficult for me to put a figure on that. The difference between them hearing something and the shock wave hitting them would be, the difference would be so slight that they probably wouldn't have had time to react, and that is suggested by, you know, the way they were found.

Q. Whatever difference there might have been would be virtually imperceptible.

A. Yes.

Q. I take it that the conditions or the possibilities for ignition that you've identified, just from your evidence in your report, that these have all been well known and well documented for a number of decades.

A. Yes.

Q. And I take it that if anything, and I guess the whole purpose of ventilation in your mine plan is to avoid these known risks.

A. Yes, indeed.

Q. And, if anything, these known risks increase the responsibility on the mine management to protect against them.

A. Oh, yes, that's true.

<u>MR. HEBERT</u> Those are my questions.

<u>MS. GILLIS</u> I have no questions.

<u>COMMISSIONER</u> Mr. Rafuse?

<u>MR. RAFUSE</u> Yes, Mr. Chairman, I have one brief question for Mr. Brookes.

<u>EXAMINATION BY MR. RAFUSE</u>

<u>MR. RAFUSE</u> I'm not certain Mr. Brookes would be able to answer this and, if not, you know, he's certainly welcome to defer on this, but, Mr. Brookes, I realize that this question may be impossible to answer given the very brief opportunity that you had to inspect the mine

underground. But would it be possible, in lay terms perhaps, to estimate, or more fairly, guesstimate the force of this explosion perhaps referenced to tonnes of TNT?

A. No, I couldn't answer that one off the cuff at all, I'm afraid.

MR. RAFUSE Thank you, Mr. Brookes.

COMMISSIONER Mr. Endres?

EXAMINATION BY MR. ENDRES

MR. ENDRES I trust my recollection is correct that in your first report in 1992 there was no reference to the boom truck as being a possible source of ignition.

A. No.

Q. What changed your view on that?

A. Well, partly the doubts about the other source of the miner or the bolter. But what I have already said, I think, that the evidence that the boom truck engine was probably running at the time of the explosion made it a possibility. If it had just been parked there, I don't think there would have been that danger.

Q. If you can take a look at Exhibit 59 at page 27, there's a photograph of the boom truck.

COMMISSIONER What was that number?

MR. ENDRES 27, Exhibit 59. You were speaking earlier about the quiet zone around the boom truck and there does

appear to be some debris and damage in that picture.
A. Well, it's difficult to say what. It looks like a cable or something that's just fallen down on the side here. There's not a lot of material there. The spots do seem to be intact in what would be the SW 2-1 roadway. There's this sort of stuff around the boom truck is the wire from the ventilation ducting, I presume. There were a few sort of -- I don't know what these things are here, pieces of timber, but --
Q. There's some debris there; that's apparent from the photograph.
A. Pardon?
Q. There's some debris in the photograph shown.
A. Yes, but I don't know whether that's stuff that's been left there or discarded or, you know, where it's come from.
Q. I see. If you take a look at the photographs showing the faces of the Southwest, we can start with 21, Photograph 21. It seems to be certainly no worse when it comes to damage to the equipment, or am I missing something there?
A. No.
Q. So that is very comparable in the sense when we're looking for quiet zones. And the same goes for Photograph 22, which is another photograph of the same

bolter, the left-hand face. No obvious damage to the machine there. In fact, there's a drill steel lying still, you can see that, on the left side.
A. Yes.
Q. And if there had been any force of explosion, would you expect that to be in that position?
A. No.
Q. If we look at Photograph 24, the continuous miner at the face of the Southwest 2 No. 1 road, do you see any explosion damage there?
A. No. Well, there's very little there to be really moved, I suppose. There appears to be little damage or no damage to the --
Q. And then we are back to 25 that Mr. Merrick has already pointed out to you.
A. Yes.
Q. Back of a shuttle car.
A. Yes.
Q. Again, if I may say so, there's not an appearance of great damage by explosion.
A. No.
Q. Nor burning.
A. No.
Q. So we have these, if I can call it that way, quiet zones and they would be identified regularly and

properly, I take it, as perhaps the centre of the --
A. Yes, I think the difference there is that, for example, 25. You're near the face of the heading and the same in Photograph 24, you're near the face of that heading. And the same with 22, you're up near the face of a heading. 21. I think what I'm trying to get at is that where the boom truck is situated, you're in kind of an open area. Where the explosion, if it started at that point from a pocket of or an accumulation of gas, the explosion has the opportunity of travelling in several directions, where at a face, it's either travelling toward it or if it was started there, it would be travelling away from it.
Q. I take it though all of that does not mean that you would want to change your No. 1 ranking as to the source of ignition.
A. No.
Q. That just confirms that the face, one of the faces, was the most likely source.
A. Yes.
Q. Or place of the first ignition.
A. Sorry, you're saying that it would confirm?
Q. The photographs, they do not undermine your ranking of the source or location of the ignition.
A. No.

Q. They confirm your ranking, do they not?
A. Yes, I think so.
Q. One thing that's been bothering me, the photographs show a lot of grey material. You were down. You were in the mine. Not in that location, of course, but we see a lot of the photographs have this grey material. Is that what you saw when you were in the mine?
A. No, I didn't see any -- I think one of the Dooleys said there was a strange grey dust over the area, but I don't know what that was. I can't recall seeing anything like that in the area I was. But in the area where in the No. 1 roadway, stone dusting had taken place by the time we went down. So it wasn't the original condition. And the little bit of the No. 2 return that we saw, the floor was very wet and kind of sludgy there. No, I didn't notice any powder of that description.
Q. But the colour of coal we saw yesterday, coal dust is black.
A. Yes.
Q. It's not grey or a shade of grey.
A. Yes, that is a mystery. I don't know really what that was.
Q. To what extent, Mr. Brookes, does your inclusion of the boom truck as a possible source of ignition depend on Dr. Brookes' theory about a layer -- Dr. McPherson's

theory about a layer of gas from Southwest 1?
A. Yes, it is dependent on that, yeah, on the formation of that layer, yeah.
MR. ENDRES Thank you.

EXAMINATION BY MR. MERRICK

MR. MERRICK Just one re-direct, Mr. Brookes, going through the photographs that Mr. Endres referred you to, I just noticed one thing that I thought I'd get you to comment on. If you start, I think, at -- If we start with Photograph 25, which is the back of the miner, we see that piece of ducting still there.
A. Yes.
Q. If you then turn to page 26, this is a photograph further back in that same Southwest 2-1 Road and it's looking up toward the back of the shuttle car. We can't see it in the darkness.
A. No.
Q. But we do see the coils of wire coming out the right-hand side.
A. Yes.
Q. Which would be the remains of the ducting that had been there further outbye, is that right?
A. Yes.
Q. And that obviously or we are taking to be the remains after it was burned.

A. Yes.

Q. If you can then take a look at Photograph 20, this is the back of the bolter on the Southwest 2-B Road. Do you see that wiring on the left-hand side?

A. Yes.

Q. Would that be the same kind of wiring?

A. Yes, it looks to be like it, yes, in that case with a little bit of the material still left on the support rings.

Q. So if we're looking for quiet zones, it would appear that there were certainly at least more flame in that heading at that location than would have existed at the back of the continuous miner.

A. Yes.

Q. And if we look again at page 21 --

COMMISSIONER Photograph 21?

MR. MERRICK Photograph 21, that's right, this is now the back of, I think, the Southwest 2-1 Road, view of bolter and the left-hander.

A. Yes.

Q. And, again, that wiring on the right-hand side of the photograph? Would that be the wiring from the vent tubing?

A. On Photograph 22 --

Q. 21.

A. Oh. Yes, I would say that was, yes.
Q. And that was burned again.
A. Yes.
Q. Indicating certainly more of a burning action in that area than we would have seen right up by the continuous miner.
A. Yes.
Q. Are you able to draw any conclusions from that as to whether there was more flame propagated into those headings?
A. Well, yes, obviously there must have been more prolonged burning to cause that degree of damage to the ducting in those areas.
Q. Bearing in mind your comments about the ability of methane alone to have burned that, are you able to draw any conclusions as to whether that may have been a methane-fuelled flame alone or whether it may have been a methane and coal dust-fuelled flame? I recognize what you told me earlier, that you can burn that ducting if you've got a very rich methane mixture.
A. Yes. No, from looking at that degree of damage, I don't think I could say, you know, whether it was just -- It could have been just pure rich methane air flame towards the upper limit, slow-burning flame, which is what you might get as you'd approached the face of that

heading if the flame travelled up.

Q. But if, indeed, we now have concentrated significant burning going on in, I guess, both this heading and in the heading with the other bolter, and I'm trying to make sure I've got the right headings here, the other bolter in here, is that consistent or inconsistent with your opinion that the flames started here, worked its way out, building as it went and went into other headings?

A. No, that's not -- That would be consistent with what I say, yes.

MR. MERRICK Okay. That's all I have.

COMMISSIONER Thank you, Mr. Brookes.

THE WITNESS WITHDRAWS

MR. MERRICK That's it for this afternoon.

COMMISSIONER We will adjourn until 9:30 on Monday then.

INQUIRY ADJOURNED (TIME: 2:59 p.m.)

REPORTER'S CERTIFICATE

I, Margaret E. Graham, Court Reporter, certify that the foregoing is a true and accurate transcript of the evidence taken by way of recording and reduced to typewritten copy.

Margaret E. Graham

DATED this 23rd day of November, 1995, at Stellarton, Nova Scotia.