DAY 9

NOVEMBER 21, 1995

WESTRAY MINE

PUBLIC INQUIRY

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

PLACE: Stellarton, Nova Scotia

COUNSEL:

Solicitors for the Commission: Mr. J. Merrick, Q.C., Ms. J. Campbell, 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. Art Fitt, Town Councillor

Representing the Canadian Union of Public Employees: Mr. Robert Wells

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November 21, 1995 - 9:33 a.m.

COMMISSIONER Good Morning.

ALL Good Morning.

DR. MALCOLM J. MCPHERSON, previously sworn, testified as follows:

EXAMINATION BY COMMISSIONER

COMMISSIONER Dr. McPherson, before you continue on with Mr. Merrick, there's a couple of things that I just want to clear up, some confusion I have in your testimony of yesterday.

One point you raised and I made notes about it, the ventilation infrastructure as set up in the Westray Mine, you indicated was adequate for the short life of the mine. Now I presume you mean by that it was adequate for the development of the mine as it had progressed up until the explosion?

A. Yes, sir.

Q. Okay. Had the explosion not occurred and had the development of the mine progressed according to whatever plans there were, can you project how long the ventilation system would have remained adequate?

A. I hesitate to project in terms of time, but in terms of the physical development of the mine, by the time they had opened up another two, maybe three sections, like the Southwest 1, Northwest 2, North, et cetera, then at that time they would be finding themselves a little short of availability of infrastructure air because of the limitations of the slopes, particularly.

Q. So the ventilation system as designed was not designed for the projected life of the mine?

A. I've seen no evidence of plans that predicted the further development of the mine beyond the first four years.

Q. Okay, fine. One other point that I'm sort of confused on. The ventilation system in place at Westray Mine was an exhaust system. The main fan was an exhaust fan.

A. It was an exhaust system, yes.

Q. There were segments of the auxiliary fan infrastructure within the mine that were of a forcing variety. Is that correct?

A. Those that I have examined, sir, I believe were all exhausting. There were small segments, yes, you're correct. There were small segments, as I indicated in the North section, there was a short force section, a force system in operation at that one place.

Q. Is that contradictory to the main system or complementary to it?

A. Neither, Mr. Commissioner. The auxiliary ventilation system is separate from the main infrastructure system in the sense that the main infrastructure is concerned with the progression of the major air flows through the main intakes, main returns. The auxiliary system deals with the ventilation of the headings that have no connection at the far end. So they are separate. They are different.

Q. So the fact that this was a forcing fan in one location doesn't mean very much in the big picture, does it?

A. With one rider, and that is you recall we talked about the recirculation that was taking place in the North part.

Q. In the north, yeah. That's the series.

A. Yes.

Q. Okay, yeah.

A. That recirculation was induced because of the out flow from the exhausting auxiliary fans projecting air in the same direction as the main infrastructure air flow to the extent that the return in that section of the mine was pressurized above the corresponding section of the intake, which is why recirculation took place.

Q. That made the recirculation, yes, because the air seeks lower pressure.

A. That is correct.

Q. Yeah, okay.

A. So, in that sense, the out flow from those exhausting auxiliary fans was assisting the direction of the main through flow, assisting it too much to the extent that it was --
Q. That it was recirculating.
A. Pushing air back around, yes.
Q. Okay. And, of course, I think you said that the forcing, the ventilation system anticipated by the Nova Scotia legislation was a forcing system?
A. The legislation mandates a forcing system for auxiliary ventilation, yes, sir.
COMMISSIONER Okay, fine. Thank you. Mr. Merrick?

EXAMINATION BY MR. MERRICK

MR. MERRICK Dr. McPherson, just a couple of questions on that. To begin with, this business of whether they had the forcing system units as well, you described yesterday, and I'm going to use that bottom map, the colour-coded one, you described a forcing system in this heading, I forget the name of it.
A. Yes.
Q. It's the northeast heading, a very short one going past that crosscut. Were you able to find any other forcing auxiliary -- Sorry, were you able to find any other auxiliary fans in the forcing mode, or were you aware of any other auxiliary fans in the forcing mode?

A. I don't recall seeing any, Mr. Merrick, in the forcing mode. I would like to re-examine the ventilation, the exhaust, the duct systems again before being positive about that, but having been through this several times, I don't recall any other forcing system specifically for the purpose of ventilating headings.
Q. All right. One question on the recirculation that was occurring in the North Mains. You've pointed out in answers to the Commissioner that there were a series of exhausting fans working around the top of the North Mains. They would not only create a high pressure in the return, but I would assume that they would be creating a lower pressure in the intake road leading up to them, would they?
A. It's not quite as simple as that, I'm afraid.
Q. All right, well, let's --
A. Do you want me to try to explain?
Q. No, that's fine. That was my physics 100 surfacing after a 25-year layover. While we're on the topic of the auxiliary fans though, there is one thing that I do want to just supplement from yesterday. You will recall that -- Just give me a second here. You will recall that in Exhibit 35-A, and we'll just turn to that for a second, at page --
A. 35-A?

Q. 35-A at page 136. That was -- 37-A, I'm sorry. I've got 35 on the brain. 37-A.
A. And the page number again?
Q. 136.
A. Yes.
Q. That is the letter of October the 15th from Westray to the Nova Scotia Department of Labour seeking approval for auxiliary fans. And that letter refers to the fact that they're enclosing a copy of our ventilation plan. Yesterday when I took you through this letter, we didn't deal with the plan itself. You have in front of you on the desk a plan that's been marked Exhibit 75.
A. Yes, go ahead.
Q. Is that the ventilation plan that you understand was enclosed with that letter?
A. Yes, I believe this was the one.
Q. And it shows the development of the mine at that point in time at least down to just the very beginning of the Southwest entry, just down past 10 crosscut, is that correct?
A. Yes.
Q. So that the mine was still in its relatively early stages of development?
A. Yes.
Q. It shows fans and the type of fans in some of the

headings just starting into the Southwest district?
A. Yes.
Q. And what kind of fan system does it show?
A. These are all exhausting fans into the headings. There is one forcing system that is not ventilating a heading but appears to be ventilating a section of what would otherwise be a through-flow circuit which has been blocked.
Q. That's up in the Southwest?
A. In the Southwest, yes.
Q. What heading is that? Can you identify the road on that?
A. The headings are not numbered on this plan, but I'll try to identify it on the larger plan. Okay, if you go up the slopes, the short -- the length of forcing ducting was around this corner.
Q. So that's coming off C-1 road around onto Southwest Mains 2, according to the diagram under tab 11 of Exhibit 45?
A. Yes.
COMMISSIONER Southwest Mains 2?
MR. MERRICK Southwest Mains 2. In fact, your diagram right at the top, it's a little larger.
A. Yes, this shows it rather nicely. The length of forcing fan ducting was around this corner and the

blockage I referred to, which is shown on the ventilation schematic is also shown on this map here. Two letters B.
Q. Yes, you're referring to the map that appears at Exhibit 45, tab 11, the blow-up of the Southwest district.
A. Thank you.
Q. Okay. So that's the ventilation plan that was sent into the Department.
COMMISSIONER Exhibit 45, tab?
MR. MERRICK 11, the blow-up of the Southwest district. It's the map, exhibit book version of the map the witness is referring to. Now when they sent that letter in, the only thing they were showing, that was about the full extent of the Southwest district development that was shown on that map, if I'm correct.
A. Yes.
Q. Would they have needed and been using auxiliary fans prior to that request to the Department for authorization?
A. Yes, sir.
Q. Why would they have needed auxiliary fans if they were just starting into the Southwest headings at that point?
A. In order to make the drivages in any development, it is clearly necessary, if you refer to any section of any

of the plans, it is necessary, for example, right here before we got to this stage, to drive forward on this one, to drive forward on this one before they could form the crosscut. In other words, during the development of this or any other mine, there are times, inevitably, when blind headings have to be put forward. Those blind headings can only be ventilated by some form of auxiliary ventilation.

Q. And that would be equally true to driving the main entries; for example, just out by No. 9 crosscut on the two mains before they had formed the No. 9 crosscut; they would have had two blind headings.

A. Yes, and, indeed, that would be the case all the way down the slopes when they were driving those.

Q. So they must have been using auxiliary ventilation of some form even prior to this application?

A. Yes.

Q. All right. Let me take you back now to where you left off in your evidence last day. We had been talking about the North Mains and the recirculations that were occurring there, and you expressed your opinion as to the ventilation system that was being used. Can I take you to Exhibit 37-A, the Manager's Safe Working Procedures, particularly at page 119? This is that set of rules that we looked at yesterday.

A. Yes.
Q. And at the bottom of page 119, there is the reference to series ventilation and "The rule is that series ventilation will only take place when the dilution ratio is not less than three to one of intake to return air (See Diagram 7) or when the maximum concentrations of the following are not exceeded. If any one of the above are exceeded, series ventilation will not take place."
What do you say as to the adequacy of that rule in dealing with series ventilation?
A. The rule immediately above, Rule 5, refers to the quantity of air being taken by the auxiliary fan will not exceed 30 percent of the quantity passing the auxiliary fan. That is within the 40 percent limit mandated by the law. So with that in mind, now move on to Rule No. 6. I think, Mr. Merrick, we do have to refer to the diagram that is referred to on this page, Diagram 7.
Q. That's over on page 132?
A. 132. Diagram 7 is showing a forcing auxiliary system. We referred to this one yesterday. It is showing some examples of air flows. In this case, we see an air flow of 22.5 cubic meters per second progressing along the intake, the left side entry. The diagram is depicting one-third of this, 7.5 cubic meters per second, being taken by the first auxiliary fan into what is shown

there as No. 1 heading. That leaves 15 cubic meters per second to progress onwards past the fan but not through it at 15 cubic meters per second, then joins with the 7.5 returning from the heading to give again the 22.5 through the crosscut.

Now I've taken you through those numbers in order to come back to paragraph six on page 119.

COMMISSIONER Excuse me, before you come back there, Doctor, you say the 15 would go up to the crosscut and it will bypass the fan, go to the crosscut and then will take a right, eh?

A. Take a right and be joined --

COMMISSIONER By the 7.5.

A. By the 7.5.

COMMISSIONER Where did that 7.5 come from then?

A. That 7.5 initially was taken by the fan, taken through the ducting up to the face of the heading.

COMMISSIONER But how did it then get over to two?

A. This is a blind heading, Commissioner.

COMMISSIONER Yeah.

A. So coming out of the end of the duct up at the face will be 7.5. The only place it can go is back along there.

COMMISSIONER Okay, I've got it. Thank you.

DR. MCPHERSON Proceed?

MR. MERRICK   Keep going, yes.
A.   So coming back to page 119 now and let us take another look at this paragraph, this Rule 6. Series ventilation will only take place when the dilution ratio is not less than three to one of intake to return air. Now what does that mean? Three parts intake to one of return. Is the three parts intake referring to the 22.5 cubic meters per second or is it referring to the 15 cubic meters per second, which is the intake going into the crosscut?
Q.   So as I understand your problem, his text that says that you can do it provided the dilution ratio is not less than 3.1. When the air divides and one-third of it is taken by the auxiliary fan, that's one-third to two-thirds. But when it comes back out and it's diluted, it's now a ratio of two to one.
A.   Two to one.
Q.   So that it's 7.5 cubic meters being mixed with 15 cubic meters, which gives a two to one ratio.
A.   That is our problem.
Q.   And I would assume that his text would have to refer to the ratio when the mixing is reoccurring or when the mixing is occurring with the return air coming out of the No. 1 heading. So his diagram and his text don't mesh.
A.   The problem I find with it is that this paragraph is

ambiguous. It is not clear.
Q. Certainly the intent of the paragraph, I would assume, would be to lay down the restrictions as to the ratio when the air is coming back out of the heading, because that's the critical mixing point, isn't it? That's where you're going to get some degree of methane coming back out.
A. Yes.
Q. All right, so we've got a problem with the Manager's Rules with that. What about the rest of the rule? For example, you see where he says that series ventilation should not take place when methane level is in excess of .75 or 75 percent.
A. .75 percent.
Q. .75 percent, sorry. What do you say as to that?
A. Well, we have a plethora of information from foremen's reports that concentrations in excess of .75 were measured on a number of occasions in the headings. We also have numerous indications of the continuous miners having to be stopped or stopping because of gas problems. It would seem that this rule referring to series ventilation not being used when the methane exceeded .75 percent was not followed.
Q. So that part of it was not followed. Let me take you back to a second to the one-third -- one to three

mixing ratio that this diagram at least -- sorry, that the text seems to mandate that the diagram conflicts with.

On your review of the auxiliary ventilation that they were doing, are you able to tell us whether they were always staying within the confines of this Manager's Rule in relation to a three to one mixing ratio?

A. Mr. Merrick, I would have to check the numbers one by one to each of the ventilation so-called "surveys" to answer that.

My sense is that in the Southwest section that there was, indeed, sufficient air flow in the infrastructure to comply with this 30 percent, this 3.1. For two reasons I say that. One because, and let me repeat myself, that the through-flow ventilation system was adequate in the Southwest coupled with the fact there was so little air flow going through the headings anyway that it would not have been difficult to vastly exceed the three to one or the 30 percent ratio.

In the North workings, we have the complication of the recirculation that we talked about yesterday. So we are not at all certain on the degree of through-flow fresh air that was taking place up there.

Q. So that would be very hard to determine because, as you pointed out to us, we had recirculation in various

locations, not just around the very North part, I guess that's through -- that was an unnamed crosscut inbye No. 4 crosscut, but we also had recirculation going in through No. 4 crosscut. And we also had recirculation going in through No. 2 crosscut.
A. Yes, sir.
Q. So that at almost every crosscut, there was recirculation occurring.
A. And in the Southeast as well.
Q. And in the Southeast as well. All right. You have reported -- You have stated in your report at page 12, this is tab 3, page 12, that in Section 3.3.1, headings ventilated in series, you make reference to the fact that they had been increasing the blade settings of the main fan, and you say that that seems to have occurred on two occasions. Once, I guess, towards the end of March.
COMMISSIONER Where are you reading that, Mr. Merrick?
MR. MERRICK Down in the bottom paragraph, page 12 of the report, middle of that paragraph.
COMMISSIONER 3.3.1?
MR. MERRICK Yes.
COMMISSIONER Okay.
MR. MERRICK About the middle of the paragraph, it says: "During February and March '92, the ventilation survey maps from Westray indicate periods when three or

four headings appear to have been ventilated in series, Increasing the blade setting of the main fan from 17 to 27 degrees towards the end of March provided enhanced air flows in the ventilation infrastructure."

Let me take you to the first change that is recorded. Going again to 37-A, if you can turn to pages 47 and also 52. Both pages, the first one on page 47 is a note entitled "Ventilation Survey, February 26, 1992." The second is one of their purported ventilation surveys, again as of February 26th. On page 47, we see where the blade angle on the main fan changed from 12 degrees to 17 degrees since the last survey. Can you tell me what they were doing there?

A. The purpose of increasing the blade angle, this is a mechanism by which the pressure volume duty of the fan can be adjusted. If you imagine, Mr. Merrick, the blades of an airplane propeller, you'll notice that those are at an angle and actually twist as one comes along from the root to the tip of the blade. An axial flow mine fan, the type they were using at Westray, operates at a similar manner. Now by actually altering the angle of the blade, here is the hub, here is the air flow, by actually altering the angle of that blade, one can change the volume flow and pressure characteristics for any given resistance that the fan is faced with.

So by altering, in this case increasing the blade angle, they were able to increase the air flow passing through the fan, the main fan, and therefore, the mine.

Why were they doing that was your question. We can only assume that they wished to increase the total amount of air going around the main infrastructure of the ventilation system, and the reasons they wished to do that presumably were concerned with what they regarded as inadequate air flows through that main infrastructure. We have the problem, again, of the recirculation that they were clearly conscious of in the North workings with returns which were at a higher pressure than the intakes.

One approach to that would be to increase that pressure from intake to the return in the correct direction by beefing up the main fan system. That is one reason that I can think of why they may have wished to have done that.

The other reason, of course, is that as, and this is quite normal, as a mine does progress and opens up more areas requiring more air, then adjusting blade angle is one of the ways of increasing the total ventilation through the mine.

Q. In your report, under tab three, you have a table at page nine in which you have logged the air flow, intake air flow measurements based on those ventilation air flow

measurements that were recorded by Westray. And does that blade change on February the 26th reflect itself in your air flows?
A. Yes, sir. If you look at the entry on that table for February 19, you'll see the air flow in the main slopes, and I've identified where these specific measurements were made. This was the air flow in the main slopes in the vicinity of Crosscut 9, towards the bottom of the slopes. On February the 19th that air flow was 144,000 cubic feet per minute, and one week later it had jumped up to 176.7. That was a reflection of the blade angle being increased from 12 to 17 degrees.
Q. So the -- that demonstrates the improved performance that can be achieved by changing the blade angle on your main fan?
A. Yes.
Q. And subsequently we see another jump at the end of March, or between March 18th, '92 and April 2nd, '92, and that would reflect the second adjustment that took the fan angle up to, what was it, 27 degrees, I guess. So that would be consistent with improved performance by adjusting your main fan?
A. Yes.
Q. Let me just come back for a moment to your opinion as to what they were trying to do. And I just want to

make sure I understood what you told us a second ago.

We've seen in the ventilation reports that we went through yesterday that during this period of time they were logging air flow through the crosscuts up in the North Mains, air flow going from the return into the main intake. So what you're saying is that it -- that might have been at least one of the reasons that they were hoping to increase the pressure in the intake side of that circuit and thus reduce or get rid of that short circuiting, that air flow through the cross -- through the stoppings?

A. That is one reason, yes.

Q. Okay. I take it that it does indicate some attempt to solve the problems that they were experiencing?

A. Yes, sir.

Q. Okay. Now do you want to move on or are you looking for something you want to give me?

A. The other thing that was going through my head, Mr. Merrick, was that increasing concerns about gas concentrations in the headings and the vicinity of the headings, would have been another impetus for the management to want to increase the main through-flow, the infrastructure.

Q. Yes. And were there reports periodically of gas readings in the headings or in the vicinity of the

headings that would indicate that they had that kind of situation?
A. That's what I was looking for actually.
Q. What about April the 8th?
A. That's the one I'm looking at right now.
Q. That's at page?
A. 79.
Q. 79. Yes?
A. Glancing down the concentrations of methane that were measured, one can see that in some cases these would give reasons for concern. There's a four per cent concentration of methane measured in the Southwest 4 Crosscut B Road.
Q. When it says "near back," what does that mean?
A. Near the roof, an indication of layering taking place.
Q. In fact, if you'll turn to page 24 of your report, that's part of a table that you've compiled for us in which you've gone through the reports and merely pulled out incidents of various categories. And on page 24 of your report we see April the 8th, and they seem to have logged two separate occasions when they had a gas problem in that heading.
A. Yes.
Q. At nine to nine -- somewhere in the morning at --

sorry, 9:00 p.m. they had to de-gas and again at 3:20 to 4:20 a.m. they had to de-gas the heading. What do you understand is meant by "de-gas"?

A. De-gassing procedures are referred to in the management safe working procedures. If a heading, for any reason, becomes filled or near-filled with methane or any other gas, we're talking about methane here at Westray, then that gas must be cleared from the heading according to a specified procedure. It's particularly important and particularly hazardous in situations of incline workings, again, as we have at Westray, because the methane is such a light gas it will readily collect and fill up headings that are going to the rise. And what I'm going to describe can and does occur also on the level, and it's accentuated by rise workings.

If the auxiliary ventilation is insufficient, and particularly if it is switched off for a period of time in a gassy heading, then that heading may well become filled with this explosive gas. Taking the gas out of that heading is the process of de-gassing. Now one cannot simply switch on the auxiliary fan, for two reasons. First of all because that would put a plug of high concentration methane into the main through-flow system, and that would be exceedingly dangerous to have a plug of high concentration gas inevitably going through the explosive region proceeding through the main infrastructure of the mine.

The second reason that one cannot simply switch the fans on is that when one is -- particularly when one is using an exhausting system of auxiliary ventilation as they were at Westray, that would mean that that very high concentration of gas would be pulled through and over the fan and the fan motor. These fan motors should be flameproof in a gassy mine, but even so, there is still a danger associated with pulling an explosive mixture over any electrical apparatus. So because of that, the de-gassing procedure consists of moving that gas out in small increments in a very controlled manner. It takes time; it is a dangerous procedure, and it has to be done with great care and skill.

Q. How do they move it out in increments if you can't just switch on the fan?

A. The -- there are several ways of doing it. The method which I believe is included within the manager's safe working procedures is to have the fan duct with bleed-off, think of it as a large bleed-off valve, at the side, and with a restriction on the main length of duct that is coming from the heading. Isolate the main length of ducting by this blanking off piece. Open the bleed at the side. Switch the fan on. The fan is taking relatively fresh air from the bleed at the side and one gradually and very carefully opens up the regulator on the main length, taking in small increments, gas flow through the main ducting. And the monitoring of the methane, of course, has to take place continuously downstream of the process.

Q. All right. Thank you.

COMMISSIONER Just with respect to page 24, this might be just a typo, but it shows on April 8th Southwest A and B, "9:00 to 9:40 vent tube installed and de-gassed." And then it goes, "3:20 to 4:20 a.m." I'm wondering if that should be under the 9th?

A. I believe de-gassing procedures took place twice on that shift, Commissioner.

COMMISSIONER Well, okay. But time-wise, that would have -- that 3:20 to 4:20 a.m. would have been on the 9th wouldn't it? To follow in sequence.

A. [No audible response]

COMMISSIONER Do you follow me?

A. Yes.

COMMISSIONER Yeah.

MR. MERRICK Maybe what we can do is turn to the shift reports themselves. They're in 37-B at about page 79 or thereabouts, and we can find the entry for --

COMMISSIONER 37-B?

MR. MERRICK 37-B.
COMMISSIONER "B". Okay.
MR. MERRICK Now this would be April that we're talking about.
COMMISSIONER I don't know if anything turns on that, Mr. Merrick, but it seem perilously close to the time when the --
MR. MERRICK Oh, now this is April.
COMMISSIONER Oh I'm sorry. That's right. Yes, we're a month off. Yeah. I'm sorry.
MR. MERRICK So that it may well be --
COMMISSIONER Yeah.
MR. MERRICK Just a minute now while I find the thing.
A. Can I refer you to page -- I can't see page numbers on these.
Q. Somewhere around 83?
A. It's coming earlier. What's this page number, Cynthia?
THE CLERK You have to find --
A. 10?
THE CLERK Yeah, it's 10.
A. Page 10.
MR. MERRICK Of 39-B?
A. Yes.
VOICE 37-B.

MR. MERRICK   37-B rather.
A.   37-B.
Q.   Page 10, yeah. Okay.
A.   Three line --
Q.   Yes?
A.   Can I go on?
Q.   Yes.
A.   If you look at the time, the "From/To" on the left-hand side. Left-hand side of the page.
Q.   Yes.
A.   Nine o'clock to 9:40. Read across. "Install vent tube in A and B Headings and de-gas." That is the 9:00 to 9:40 de-gassing. And further down, "3:20 to 3," -- "...to 4:20 de-gassing A Heading."
Q.   Yes.
A.   So those are the two references to de-gassing in that particular block.
Q.   So that second incident occurred on that shift, but it may have been the next day?
A.   The next day in the sense that it was past midnight, yes.
COMMISSIONER   Yes.
MR. MERRICK   Yes. Same shift?
A.   Yes.
Q.   Do you know where the gas was coming from that they

were having the problems with?
A. [No audible response]
Q. Would this be gas that was -- do you know if that was gas coming in from the old Southwest 1 District that they were having to cope with?
A. Now can we determine where these A and B Headings were? Where are we referring to here exactly? Southwest 1. So this was in the old Southwest 1 before they drew -- came out of it.
Q. We'll -- actually, we'll have evidence from the miners themselves that will --
A. Okay.
Q. -- probably clarify that. All right.
A. But we're talking about somewhere up here.
Q. Well, if it was April, it would be in the Southwest 2 District because they came out of there at the end of March.
A. Ah-hah. I was looking at the top right-hand corner of page 10, the district is denoted as Southwest 1.
Q. Yeah.
A. Was that a mistake?
Q. They're probably using that to designate the whole of the area still at that time.
A. All right.
Q. Okay.

A. Can I try to answer your question about where the gas was coming from?
Q. Yes.
A. Presumably, the fact that they were installing a vent tube indicates that actual coal mining was not taking place prior to that. It being unventilated. The fact that it filled up with gas and they had to engage in de-gassing would mean that that methane gas would be coming from the standing face and the rib sides and any coal that was left in the roof and/or floor.
Q. And if it wasn't coming from there, it would be from -- could have been coming from either that or coming in from the old working that they were in. They say "A Heading" and I assume that that could be the Southwest 2 A Road, but we'll clarify that from the people that were there. Yeah.
A. The A and B Roads are both going at -- upwards at an inclination of 13 degrees, so that would certainly assist, if that's the correct word, in those headings being gassed out.
Q. Okay. Let me pick up again where we were. You've told us about the ventilation circuits and the problems that we've had with it; you've referred us to the shift reports that -- and the ventilation measurements that were taken that refer to gas readings. Just give me your

conclusions or your understanding, if you will, on the problems that they were having with monitoring the gas levels.

To begin with, let's start with the main environment system and just your brief comments on it. This had four sensing locations, four automatic sensing locations that we've heard about, two very close to each other down at the North Mains at the very extremities of the mine and two in the vicinity, general vicinity, of the 10 Crosscut. Well, one in the vicinity of the 10 Crosscut. One little a further up the return. From what you have read about the monitoring system, what can you tell us as to how new these kinds of systems are, how frequently they've been used and, generally, how reliable they are?

A. Environmental monitoring in underground mines has been under development and continues to be under development. The early -- earlier systems date back to oh, the 1960s or so. Environmental monitoring in underground workings is considerably more difficult than it is in surface locations, buildings, for example. The reasons for that are because of the arduous environmental conditions that exist, the physical conditions, the possibility of pieces of rock, if not large falls of roof taking place. The wiring systems. The signals pass through wiring systems which have to be protected much more substantially than they would be in surface locations. So the physical environment is not conducive to a sensitive transmission -- transmission of sensitive electrical signals. That is one reason.

The second reason is that a modern mine is a consumer, a considerable consumer, of electrical power. So we have high voltage, high power equipment being used in modern mines and a mixture of high power, heavy current and light current signals as we're using for data transmission. Those two do not mix very well. Light current transmissions, data transmission systems, are particularly sensitive to small variations in voltage. So that is a second reason for underground environmental systems being more difficult than in surface locations.

Your question about the newness of this particular system. I understand that it had been installed fairly recently before the mine finished, and I also understand that it was the first system of its kind to be used in Canada. These systems do take some time to settle down, not only for the two reasons that I gave, but there's a third reason and that is that the personnel should be adequately trained in interpreting the signals, maintaining the system. And we're talking not only about maintenance of the wiring and the monitors, the actual transducers underground, but also the computer control, the hardware and the software, maintained in the surface control. We are talking about a fairly sophisticated system.

So for all of these reasons, Mr. Merrick, one can expect there to be a period, a settling down period, which may be several months, when the people are getting used to the system and, indeed, the system itself is settling down to that particular geographical location.

Q. So that if later on we were to take a look at printouts or logs or readings from this main environmental measuring system, we should not be surprised if it was showing a series of false or off errors or shut downs or readings that would seem to be electrical explained by something else other than what they were intending to monitor?

A. Precisely.

Q. And when you say an environmental monitoring system, we're now talking about this automatic fixed location sensing system that can be read in a central location on a continuous basis?

A. Yes.

Q. That is something that didn't exist prior to the '60s, you say? Generally.

A. It has been under development. The early systems of the '60s were very crude and even less reliable, much

less reliable than the ones we have today.
Q. So in mines that do not have this automatic, continuous monitoring system, the traditional way had always been then, I take it, just by your hand-held measurements that you would take using your held -- hand-held instruments?
A. That is correct.
Q. To what extent could you describe this system, to the extent that you've read about it in our data, as being state of the art?
A. It was a modern system.
Q. All right.
COMMISSIONER Can I just pursue that for just a moment? Are you saying that in the early stage the settling down period for that system, whether it be settling down because of the system itself or because of the employee getting used to the system, that you couldn't depend on the readings?
A. That is correct. That is exactly what I'm saying, Commissioner.
COMMISSIONER So -- okay. As the system settles down you still have the same electrical interference from the heavy voltage equipment. How does that settle down?
A. When these problems have revealed themselves, then steps can be taken, just like the surge protectors on our

computers nowadays, to emplace devices such as this at the strategic locations within the hardware system to help to iron out these problems. But where such devices are placed and how they're utilized, one gains from experience and must vary from location to location.

COMMISSIONER Okay. So it is just a question of adjusting the system to account for these things?

A. Yes, sir.

COMMISSIONER Okay. Thank you.

A. May I add one further thing here. When faults do arise on the system during this, or at any other time, these faults are often reflected as the system going off-line, there being no signals being recorded --

COMMISSIONER I see. Okay.

A. -- at all. When they are operating, then the signals that are received and being recorded may well be adequate and accurate. So this is not a matter of the signals giving false readings so much as them going on and off.

COMMISSIONER I see. You either get accurate readings or not at all?

A. You either get accurate readings or you get a fault indication that there's something wrong with the monitor or you get no signal at all which means the line is broken or it's switched off.

COMMISSIONER Okay. Thank you. That's what I wanted to clear up.
MR. MERRICK So that you're either getting a reading that you can rely on you're getting a reading that you can't put any reliance on?
A. Yes, sir.
Q. You can't -- usually, you cannot say that this reading doesn't make sense, but by looking at it very carefully we can figure out what it means?
A. We can attempt to do so.
Q. All right. You say that training is an important aspect. Training on how to use the system. How complicated it is? I mean, what sort of degree of training generally would you need for that kind of a thing?
A. I would have to give you a general answer, Mr. Merrick. I'm not personally familiar with the controls, the hardware or the software, of this particular system so I cannot speak with authority on this specific item. But as in all sophisticated procedures and equipment, training of the personnel who are required to maintain it and interpret the readings would obviously seem to be important.
Q. It would seem to me then it would be particularly critical in the settling down phases because you would

need somebody there sufficiently knowledgeable and capable to be able to figure out what adjustments to make. If there were changes to the hardware, that you mentioned a moment ago, there would have to be somebody there that would know how and where to do this?
A. This would seem to make sense, yes.
Q. I take it that the installation of a system like this indicates something about the mindset of management. I would presume this is a positive step in relation to looking after the health and safety of the mine.
A. Yes, indeed.
Q. This is an expenditure of money that not every mine has done and this mine did.
A. Yes.
Q. Let me, and we'll come back in a minute to some of the readings that occurred on this main system immediately prior to the explosion itself, and we'll keep your comments that you've just given to us in mind. But before we do that, I just want to take a look at some of the other problems that they were having with their monitoring or safety systems in the mine itself.
To begin with, you went through the shift reports and picked out a series of incidents. In fact, in your report, at pages 31 and following, under tab 3, you've got a section there that's entitled "Problems with

Methane Sensors and Emergency Stop Buttons on the Machines."
A. Yes.
Q. And you refer to a number of the reports or entries on a number of the reports: March 20th, 31st, April 10th, April 16th, et cetera. And all of those we can look at ourselves, but I want to look at some of the ones that you particularly highlighted for us.
Your first one, you're talking about an entry on April the 1st the you've quoted by Mr. Ellis where he states "Emergency stop to be shorted out left side of 2,000 continuous miner. I do not agree with this order. Further information needed."
If you can look to Exhibit 37-B, I believe at page 81, is the underground maintenance foremen's shift report, and where on that did you draw that comment from?
A. Just over half-way down the page under the heading "Action Items Electrical."
Q. This is a report by Mr. Ellis?
A. Yes, sir.
Q. So that's where you got your quote?
A. Yes.
Q. You aren't able to determine -- I take it there's no further information in the report that explains his comment and, in particular, his comment "I do not agree

with this order."

A. The four lines -- the three lines we're looking at appear to be the only reference to this on this particular page.

Q. In your report, you go on to refer to a second entry that says "Disconnected emergency stop button," and if you turn to page 83.

A. Yes.

Q. You're suggesting that that is probably the same shift?

A. The report signed by Mr. James, Larry James?

Q. Yes.

A. On page 83. Is dated 4-92. The month and the year. The day is not given. But by its location within the dossier of these reports, this is the location in which it appears, and one assumes it was following on.

Q. We see on the immediately preceding page, page 82, another report by Mr. Ellis. This would be on April the 2nd.

A. Correct.

Q. And in the same place in the report, he now enters "2000 continuous miner emergency stop shorted out."

A. Yes.

Q. So that the following shift, he apparently shorted out the emergency stop. Do you have any other

explanation as to that other than what you've seen on the documents so far?
A. I raise a question in my report with respect to Mr. Ellis' second report. If we come back to page 81, he is indicating there that he has been given some kind of instruction that the emergency stop on machine 2000 should be shorted out, and he's indicating his disquiet with that instruction.
On the following day, turning over one age, as you indicated, he simply states in his report, "2000 continuous miner emergency stop shorted out." Now what does that mean? Does that mean that he shorted it out or it had been shorted out?
Q. Indeed, he may have been reporting that something that he refused to do the previous shift had now been done.
A. That is my question, yes.
Q. Hmm. Let me now take you to that page 83, the one we looked at for just a second that is undated as to day. This is a report by Larry James and tell us what you found that's significant in that report?
A. Well, if you look at the second line down -- Let's look at the first line down. Equipment appears to have been initially written as 2002.
Q. Just a second now. Let me take a look at that.

COMMISSIONER Where are we?

MR. MERRICK Page 83, top left-hand corner, we have the equipment description, and Dr. McPherson has just said it looks like somebody had originally written 2002 and then subsequently added another little curve on the bottom of the two to make it read three. All right, keep going.

A. And the original location seems to have been Southwest, SW, which has been crossed out and "NE," presumably Northeast, inserted. And in the remarks column, "Internal examination carried out. Disconnected emergency stop button."

Q. Hmm.

A. And I raised some questions about this report.

Q. All right, just give them to me because we'll make sure those questions are answered.

A. My question number one is: Is this machine that has had its emergency stop button disconnected, are we talking about one machine here? If so, is it Machine 2000? Is it 2002? Or is it 2003? Or did more than one machine have its emergency stop button shorted out?

Q. And possibly if it is continuous miner No. 2000, is one foreman reporting that he doesn't want to do it and another reporting that he did it and the first one reporting in the next report that it was done?

A. Precisely. Those are my questions.

Q. All right.
A. And, of course, there's the almost rhetorical question that I ask at the top of page 32 of my report: What was it that made Mr. Ellis unhappy with the order to disconnect the emergency stop button?
Q. Now we'll hear evidence as to the emergency stop button on these machines and the various emergency stop mechanisms on these machines. But as a general rule, I take it, it's not a good idea to short out safety features built on the machines by the manufacturers.
A. Safety features are built into any equipment for that very reason, to improve the safety, so it would seem inadvisable to interfere with them in any way.
Q. Okay. Again, picking out some of the incidents that are referred to in your report, the ones that you paid particular attention to as well, on page 32 of your report, you talk about some references to methane sensors being replaced on continuous miners. Staying with the shift report, perhaps you can point out where you got this information. I'm looking at pages 84 and 85 now.
A. Well, let's take page 84.
Q. Yes.
A. A report again signed by Mr. Ellis, top of the page, the 2000 continuous miner, Southwest district, second and third lines in the remarks column, "Mounted methanometer

back in original position." And the question arises: Why had it been moved from its normal and original position in the first place?
Q. All right. The one thing we know is that there seems to be consistency that continuous miner 2000 was operating in the Southwest district.
A. Yes.
Q. Okay, what's the next report you want to direct our attention to on this?
A. Well, if you would turn over one page, the report dated April 16th. There appears to be no signature on this one, but the last handwritten line in the report and the comments at the bottom, "Sniffer is back in original position."
COMMISSIONER What page is that, please?
MR. MERRICK 85. It's hard to read because it's gotten blacked out by the photocopier.
COMMISSIONER Okay, I find it, yeah.
DR. MCPHERSON Bottom line, "Sniffer is back in original position." This is with reference to machine 2002. The sniffer, of course, is the methane monitor mounted on the machine. So, again, the same question arises: Why had it been moved?
MR. MERRICK And it appears that at the same point in time, approximately the same point in time, within a

week, two separate continuous miners are getting the sniffers put back on in position.
A.   Yes.
Q.   Okay.
A.   Do you wish me to continue?
Q.   Yeah, please, because the next shift report, page 86, also is one that you drew a particular attention to.
A.   Yes, page 86, Mr. James --
Q.   This is April 4th?
A.   April 4th.
Q.   Sorry, April 27th.
A.   27th, yes. We're back to machine 2000 and four lines down from the top in the remarks column is a reference to "bolts and nuts required to secure CH4," that is the methane sensor. So, again, there would appear to have been some previous reason for removing those nuts and bolts.
Q.   So, again, we'll --
A.   May I make a comment, sir?
Q.   Yes.
A.   These are questions that I ask and would like to see answered. The reason that I'm raising those questions is because they are questions in my mind. There may, on this page, for example, be a very good and proper reason for those nuts and bolts having been removed; for

example, to check the calibration of the methanometer. But I think these questions should be followed and answered.
Q.   Well, one of our objectives we set out in this Inquiry is to make sure we get all the questions on the table. All right, just continuing with those shift reports, you refer to one a little further over at page 88.
A.   Page 88.
Q.   This is one that perhaps is also significant.
A.   Half-way down the page.
Q.   This is on May the 5th now.
A.   This is on May the 5th. This is a report by Larry James again. Half-way down the page under the heading "Action Items Electrical." The comment is made "Trip point on 2002 continuous miner 420D," this is the methanometer, "raised from 1.2 percent to 1.5 percent was requested." In other words, the trip point on this methanometer was requested to have been set above the 1.25 percent at which electrical power should be cut off.
Q.   And I take it that the questions that arise out of that entry in that report is: Was it done?
A.   Yes.
Q.   And who requested it and why?
A.   Yes.

Q. All right. The other comments that you made as far as equipment difficulties, gas incidents, et cetera, are set out in the tables to your report. And I won't have you go through each of those. We can read them in that table. There are, however, just two additional items I want to ask you about about their detecting equipment and ventilation measuring equipment. Are you aware of whether they had difficulties with their high speed anemometer at some point in this period in the months just prior to the explosion?
A. Yes, sir, there is an indication in the exhibits that the high speed anemometer was returned to the manufacturer for recalibration.
Q. This is in Exhibit 37-A at page 57?
A. Yes.
Q. 37-A at page 57. I take it the comment that relates to that is the last sentence there in that two-paragraph report, the last part of that sentence: "...although due to the damaged anemometer, only smoke tube observations could be made. The back-up anemometer had been sent out for repair and recalibration." An anemometer is the machine, equipment, that measures air flow. This was the high speed one. What would they use that to measure?
A. Let me answer your question and I'll come back to something else. The high speed anemometer, we described

yesterday what an anemometer was. It's a little fragile windmill instrument whose blades turn with respect to the movement of air through them. These come in three ranges: Low speed, medium and high speed. And they mean exactly that. They are designed for use in low speed, medium speed, high speed situations. The measurements made in the ducts are in velocities which are obviously very much higher than in the main airways. So, for that reason, the high speed anemometer would be used preferentially for measurements of the auxiliary fan air flows.

COMMISSIONER How do you determine it was high speed? I don't see anything on page 57 to indicate that, Mr. Merrick.

MR. MERRICK No, you don't, Mr. Commissioner, and I'm going on instructions that I have been given, that, hopefully, I'll clarify later.

COMMISSIONER Okay.

MR. MERRICK One thing we know from the document is that it was an anemometer. They were still continuing to make air flow measurements in the headings themselves, although they could have been using their smoke tube observations.

I notice, however, that they did not have duct air flow measurements for the period immediately following

this entry. For example, on page nine of your report, Doctor, where you listed the intake air flow measurements and then the range of auxiliary fan air flow for two weeks following in the March 18th/April 2nd, there were no measurements at the ducts.
A. That is correct.
Q. All right. A relatively minor point, but at least tracking their measuring system. Just one fast question that comes out of that observation at page 57, what's a smoke tube observation? Because we see that every now and then in the air measurement surveys.
A. A smoke tube is a small glass vial sealed at both ends containing a chemical, typical titanium tetrachloride, which reacts with water vapour in the air to produce a fairly dense white chemical smoke. It is used by snipping off the ends of the glass vial, attaching a small hand actuated rubber bulb pump and simply pumping some of the mine atmosphere, the air, through the chemical that produces a puff of clearly visible smoke. This is used particularly in low velocity situations. It's a very crude method of measuring air velocity and one simply determines with a watch, a stop watch how long it takes for that puff of smoke to move from position A to position B. Knowing that time and the distance between A and B gives a fairly rough and ready

indication of the velocity along that path through which the smoke has passed.

Q. All right. Now let me move you to a topic of some significance. Let's talk about the old Southwest district for a moment. We have talked about gas readings. We've talked about difficulties with the ventilation system that they had, with the short circuiting. The difficulties with the auxiliary ventilation, the inadequacy to prevent layering. Now let's begin to look at a major, potentially a major source of gas.

You're aware, of course, that at the time of the explosion, the Southwest district 1 had been abandoned. What is your understanding -- Let me back up. When you abandon a working area like that, what is the normal, prudent practice as to the method of sealing?

A. There are two methods of minimizing the bleeding of gas from such old districts. Let me talk about both of those. One is the method you referred to and that is to put seals across those entries into those abandoned old workings, seals of a type that will minimize the amount of gas that bleeds out of them. This means substantial seals, not simply single wall stoppings, but double wall stoppings with in-fill of material between those two walls.

Q. Give me a physical description of one that you're thinking of?
A. Can we use the board again?
Q. We now have numbered pages. So this would be No. 1 dated November 21st.
A. Let's suppose this is the entry into the old workings. Active ventilated part of the mine, old workings, this end. The method I'm referring to, the first of the methods, is to build two walls. I've seen these as far as five meters apart, if they are also to be explosion proof. If they are not to be explosion proof, they can be at closer intervals of time. And the intervening space filled with nonflammable material. Stone dust has been used. Gypsum-based plaster has been used. Those items mixed with material from the mine, not coal, but nonflammable material, waste material, from the mine. This is the kind of seal that would be necessary to inhibit -- it will not prevent -- but inhibit the migration of methane. The reason that it will not prevent methane is -- Let me draw this a little better. These walls should be keyed into roof, floor, and sides. The reason that that by itself will not inhibit, will not prevent methane from coming out of this, if the pressure here is greater than the pressure there, then migration of the methane will still take place in fractures around

it. So the purpose of such a stopping or a seal, as it's sometimes referred to, is to minimize but not prevent the methane.

Another method of preventing this kind of migration, let us take two entries into old workings. Again, these joining through to the main infrastructure of the mine. This kind of seal could be put on both sides. Another way of preventing the methane from coming out even in this kind of circumstance is to use a so-called pressure balance chamber. Now what happens here is that in addition to these, let's put these two stoppings with a seal here. In addition to that, you build a third wall down here with space in between. Not filled in. And to devise a method by which the pressure here is exactly the same as the pressure there. The simplest possible type of system would be to put a duct, no fans, simply a duct going from this chamber into this chamber equalizing the pressures. In that case, there's no pressure differential across the old workings.

Q. Just set up a circuit.

A. There's no circuit. There's no pressure differential. There can be no movement of any gas. So that is a very powerful way of preventing methane coming out of these old workings. Now let me emphasize. This is in addition to this, not instead of. That is Method

No. 2.

This is quite a common method used in the United Kingdom. It is not commonly used, it has been used but not commonly used, in the United States.

There is a third method of handling this problem, and this is the method that issued in the United States. And that is that when we have -- Let me draw it as a block diagram.

Q. You're on Diagram No. 2 now.

A. When we have a set of old workings, again, with a potential to bleed out into the ventilated part of the mine, one way of handling this is to use the so-called back bleeder system. In the back bleeder system, a return entry is maintained along the back of the old workings. The layout is designed and set up in designing the mine for that to be maintained open, and this is connected through to the main return system of the mine. So that the seals are put on here as we described before, and any leakage that takes place is clearly going to take place from the high pressure side slowly and be pulled into that back bleeder return. And this is a method of preventing those gases from bleeding out into the main part of the mine.

Q. It would seem to me that the two systems are based on two basic theories: one is to avoid any of the gas

from the old worked out area getting into your mine, the second one is to allow it and accommodate it?
A. Yes, sir.
Q. Faced with what we see on the diagram, the maps here of the Southwest district and knowing that Westray was required to abandon the Southwest 1 district, what would you have expected to have been the intent of the mine management, a prudent mine management, as to whether they would try to completely seal off that district or whether they would try to accommodate the escape of gas into the mine system?
A. First of all, let me point out that taking intake air past the entrances to the then abandoned workings, you'll recall the air flow. It came up here, around this way, and then into Southwest 2-B, passing the entrances to Southwest 1.
The first point I want to make is that this is not allowed by the Nova Scotian regulations. The intake air should not pass areas, abandoned workings -- we can refer to the exact wording, but it is a practice that is mentioned in the law, that they should not be utilized.
What the law also states is that in circumstances where this might otherwise happen that a separate pathway be allowed for the return, for gas or air coming from those old workings to be directed directly into a return.

This could have been done in two ways.

First of all it could have been done by this method, provided this method had been laid out and had been part of the original mine design, which, of course, it was not.

And the other way of accomplishing that same end would have been to construct air crossings, an air crossing, over the intake, this intake part, to allow any bleeding from the old workings to progress into the return without contaminating the intake.

Q. Just let me make sure I've understood that. Would that be a crossing that would take your fresh air past the entrance and then up into Southwest 2 or a crossing that would allow your return air --that would have passed the old workings to get straight out to the return?

A. Either way would have done it, Mr. Merrick, as long as you keep the two separate.

Q. So you have built a duct -- for example, if you were going to keep the intake air separate, you would have built a duct past the old workings?

A. It would have been easier to actually have a ducted system from the old workings or from the front edge of the stoppings such as they were to direct it into the return and therefore not contaminate the intakes. That would have been a less expensive mode.

Q. So the first step that a prudent mine management would take is to avoid running your main intake ventilation system straight past the entrances to the old workings?
A. That is not only prudent, it is also -- would be in compliance with the law.
Q. Mr. Commissioner, you may wish to take the morning break at this point.
COMMISSIONER Okay, we'll recess for fifteen minutes, thank you.
INQUIRY RECESSED (TIME 11:04 a.m.)
INQUIRY RESUMED (TIME 11:21 a.m.)
COMMISSIONER Mr. Merrick?
MR. MERRICK Thank you, Mr. Commissioner. Dr. McPherson, we were talking about the way a prudent mine management would handle the closing off of the Southwest district, and you told me that the first thing they'd do is avoid exposing your main intake ventilation flow to those entries. What else would they do or how else should they have handled the abandonment of that area?
Let me ask it another way.
A. Yes, please.
Q. What do you understand to be the way they did seal off that area?
A. The seals -- I hesitate to use the word "seals"

because they were not seals in the proper sense of the word. The attempts to put stoppings up -- the stoppings, as I understand them, were constructed out of plywood and plastic. The first comment there is that, again, within the Nova Scotia regulations, stoppings are required to be made out of substantial material. I would hardly call plywood and plastic substantial materials from the point of view of building stoppings in mine entries. That's a general comment.

With respect to the stoppings of that type put into the entrances to the old Southwest 1, these would clearly be quite inadequate to even inhibit, never mind prevent, the passage of methane from those -- or any other gases, in or out of those old workings.

Q. Knowing -- I'm trying to quantify the significance of what they did, and just bear with me while I struggle with that for a minute. Knowing what they had in there, knowing that they got chased out of the finger panels section that we talked about with Dr. Salamon last week, knowing, therefore, that there would be a considerable crush of coal going on in there, I mean, how bad was this that they merely put up this description of stoppings that you've described of plywood and plastic?

A. Those stoppings would do little more than prevent people from going into the old district. And that, of course, is necessary to fence off old districts so that no one inadvertently wanders in there. They would perform that function. But as far as movement of air or gases in and out, they would hardly be effective in that sense.

Q. Assume for the moment that on May 8, 1992, you were taking a tour of that mine and part of your tour took you up into the Southwest district and you went by and looked at the stoppings, knew or had explained to you what was behind them and the circumstances, how concerned would you be with what you would be seeing?

A. I would be concerned, Mr. Merrick, in two senses. First of all, because it was an illegal system, having intake air passing the entrances to old workings; and secondly, I would be concerned for the safety of the mine workers, in the sense that we've already talked about, that this is a system that would allow methane to bleed out of those old workings into the ventilated areas of the mine.

Q. Well, what I'm trying to quantify, and I'm pushing you a little bit, and only go as far as you're comfortable, but recognizing that this is not the way it should have been done, how opposed -- how upset would you be with seeing how they did it? I mean, on a scale of gravity, would this be something that you would say to

yourself "Well, they've done it improperly; it's not the way I would do it. That's interesting." And move on, or would you say "What in God's name is that?"
A. I would have suggested that they provide a means of bleeding that gas from the old workings into a main return. And we've already talked about a method that could have been implemented by ducting air from those old workings into an improvised air crossing into the main return.
Q. All right, let's talk for a minute about the volume of gas that may have been being generated in that old area.
A. Yes.
Q. You deal with that on pages 10 and 11 of your report. And tell me how you do that and what you -- it is that you are calculating. I take it that you are arriving at a quantification of the amount of methane that may well be being produced in the old workings, am I correct?
A. Yes. And specifically, on April the 2nd when the measurements that I'm going to refer to were taken.
Q. Yes.
A. Do you want me to go through?
Q. Please.
A. Yes.

Q. We won't bother going to the shift -- the ventilation measurements that show those readings because they're in the documents; we looked at them yesterday. All right?

A. All right, let me refer then to the map. On April the 2nd measurements of methane concentration were made at the locations that I've identified on top of page 11 of my report, Southwest outbye 4 Crosscut. I'm pointing to the location on the map. This is 4 Crosscut. Measurements of methane were made at that position. Two measurements were made, and those are the numbers I've indicated at the top of page 11.

Q. Yes.

A. A measurement was made of 2.5 per cent methane which was in the general body of the air flow. A second measurement was made, described in the report as "near the back," and this means near the roof, of nine per cent, indicating that methane layering was, indeed, taking place at that position at that time. Also indicating the nine per cent is close to the concentration of methane that corresponds to maximum explosability of the gas. Maximum explosability occurs at 9.5 to 9.6 per cent. So we were very close to the maximum explosibility of a methane-air mixture.

So we had a fairly high concentration of gas coming out at roof level and also a significant concentration, 2.5, at the general body. 2.5 per cent is the concentration in Nova Scotia at which personnel should be withdrawn. But this was at the entrance of the old workings and not in the main ventilation.

On that same day and during that same so-called "survey," a measurement of air flow was made in the C-1 Road inbye 3 Crosscut. Here is the C-1 Road, 3-1 Crosscut. An air flow measurement was made at that position. This is air flow that would then progress into and around the Southwest 1 workings. Clearly, there were no substantial stoppings at that time to allow that amount of air flow to progress around. It may not have been the full air flow because we have another passageway which is blocked, but there may well have been some additional air entering the old Southwest 1 through that blocked passageway.

Q. Just looking at that blocked passageway for a moment.

A. Yes, sir.

Q. The two stoppings that we talked about a few minutes ago of plywood covered with plastic we see on the A -- C-1 and B Roads.

A. Yes.

Q. The third one that goes up 2 North A is identified

as being "chocks only, no plywood" --
A. Yes.
Q. -- and a little further up "blocked ground fall No. 4." How adequate is a ground fall to blockage of passage of air and ventilation into that area?
A. It depends clearly on the type of rock fall. It can vary from being a very minimal additional resistance to air flow through to being a substantial obstruction. Indeed, one is often misled visually by looking at a fall and seeing it going way, way up there with no possibility of people going over that. But nevertheless there still can be significant amount of air leaking through.
Q. All right.
A. So it's impossible to say is my answer.
Q. All right. Let's come back to your description then. You're saying there could be air flow going into the old workings?
A. In addition to the 20,875 that was measured at this point. So it was at least that is the point I'm making.
Q. Yes.
A. Okay? So now we have -- and all of that air would come out on the B Road where the 2.5 and the nine per cent methane concentrations were measured. So now we have a minimum value of the air flow and the methane concentration at this point. I have taken the 2.5 per

cent concentration as a conservative value, the lower of the two concentrations that was measured, multiplied it by the air flow, 20,875, to arrive at the proportion of that movement of gases, air and methane, that was, indeed, methane. The calculation is on the top half of the page, page 11, and gives us a value of 522 cubic feet per minute or .246 cubic meters per second of methane. So at that time, April 2nd, we have a direct measurement of the amount of methane that was being produced in the Southwest 1.

Q. Because we know you've used in your calculations the reading that was taken right at that point which would be coming out of the Southwest 1?

A. Methane concentrations. Yes, sir.

Q. And indeed, since you prepared your report, Doctor, there is now some evidence to indicate that the stoppings that are referred to in that diagram may not in fact have been constructed until on or about April the 13th. Now we will hear evidence later on as to exactly when they would have been constructed --

A. Yes.

Q. -- but assuming for the moment that that may be so, then that would strengthen your -- or that would be consistent with what you've calculated here?

A. Well, indeed, it's -- this is the reason they still

had 20,875, at least, going around that district, yes.
Q. All right. So that's the volume -- or that is the amount -- have I got it correctly? That that is the amount of gas that would be being made in that old area?
A. Yes.
Q. So that tells us the amount of gas that may well be coming out of that area?
A. Yes.
Q. Okay. Now let's talk about what happens to that gas when it comes out. In your report you have concluded that gas coming out of that old working area would layer and go up Southwest 2-B Road. Up the incline.
A. Yes.
Q. Tell me how you have arrived at your conclusion that layering would, in fact, be occurring.
A. We're still on the April 2nd scenario.
Q. All right.
A. With substantial amount of air still going around the Southwest 1, it was being ventilated. And we've used the air flow, the ventilating air flow, combined with the general body gas concentration coming out of the return side in order to calculate that amount of methane. The majority of the methane coming out of the Southwest 1 at that time, because it was ventilated, would be in the general body and there would, in addition to that, be

higher concentrations at roof level as, indeed, was measured. It is those higher concentrations at roof level that form the layer, not the general body concentration.

Now the difference that would occur when those plywood and plastic stoppings were constructed after this date, would be to cut down very substantially the amount of air passing around Southwest 1. That was the primary objective to so-call "seal them off." And it would therefore reduce substantially, that amount of air and that amount of dilution that had previously been taking place. Dilution of the methane.

So now we have a situation, after the stoppings are put on, where we have a completely unventilated section, Southwest 1, but which is still producing methane. The cessation of ventilation will have very little effect on the rate at which methane is produced. The rate of methane production will vary with time. It goes through a decay process, but it will not be affected one way or the other by the presence or absence of passage of air through the old workings.

So what will then be coming out of Southwest 1 around and over those so-called "seals," would be high concentration methane, and that is the situation which leads to -- which favours the production of methane

layers.
Q. Yes. Now take me through your calculations as to how you -- you've got a section in here on calculating the fact that layering was, in fact, occurring. Let me just find it in your --
A. This is Section 8, page 35, Mr. Merrick.
Q. Yes. Let me just catch up to you. All right. And this would be calculations that were done based on measurements taken May the 8th?
A. Yes, sir.
Q. And what did you do there and where does that lead us?
A. In Section 8 I have used data and analysis to indicate that there was a high probability of methane layering taking place into and up the Southwest 2-B Roadway. In the table on the middle of page 35, I have taken survey data, the air flow measurement data, at the location of the V-11 ventilation station that was, I will point it out on the map, in Southwest B Road return airway. Those air flow measurements are indicated under the heading "Air flow cfm" in the table. I have chosen that location to base this analysis on because we have methane concentration, general body methane concentrations, also measured at that same station.
So throughout the month, April 8th to May 8th, we

have air flow and methane concentrations measured at that point and this is the return air from the complete Southwest sections.

If we, line by line, multiply the air flow by the methane concentration, we arrive at the amount in cubic feet per minute of methane flowing. You'll notice at the top of my last column, fourth column, methane flow is concentration times air flow. So it's simply Column 2 multiplied by Column 3, gives us the methane flowing out of the total Southwest region. This varies from 570 down to 442 cubic feet per minute. I've taken an average of 523. This is methane coming out of that total Southwest district.

At this stage, I have made an estimate. I'm going to come back to a rationale for that later, but, for the moment, I've estimated that this 523 average volume of methane which, of course, is coming partly from the old Southwest 1 and partly from the current Southwest 2 workings, I've estimated that approximately half of that was coming from the old Southwest 1 workings. Specifically, I've estimated of the 523, 250, a little less than half of that methane flow, is coming from the old Southwest 1 workings.

Now let's hold that in our minds for a moment and take a look at the Southwest 2 area itself. On May 8th,

an air flow measurement was made at this location, Southwest 2-A, inbye Crosscut 1, of 59,800 cubic feet per minute. It is actually marked on this map.
Q. Yes, that's the measurement as of May 8th.
A. As of May 8th.
Q. And that's taken off the ventilation, purported ventilation surveys, that are in the documents?
A. Yes, sir. I've taken -- This would be an approximation, therefore, of the air flow that was progressing around this loop. There would clearly be some leakage here, but this gives us an indication of what we've been calling the infrastructure or through-flow ventilation for that Southwest 2 loop.
I've, therefore, assumed that that would be the same air flow as passing up Southwest 2-B. That is more than an assumption; that is a certainty because there's no other entrances into or out of Southwest 2. So what goes in here has to come out in the return.
So we can take that air flow as being representative of the Southwest 2-B, even though it was, in fact, measured in Southwest 2-A. Now taking the dimensions, the average dimensions, of Southwest 2-B, we're going to concentrate on this rising intake now. I've taken the dimensions of that to be six meters by 3.5, giving an area of 21 square meters. Six multiplied by 3.5 gives us

21 square meters. If we divide the air flow by the cross sectional area, we arrive at the air velocity. Remember we had that equation on the board yesterday?

Q. In fact, you're now doing that calculation for us for this date in that location.

A. Right. We're saying Velocity U is Air Flow Q divided by cross-sectional area, which is the same equation as one of those we had on the board yesterday. And that gives us a mean velocity proceeding up Southwest 2-B at 1.34 meters per second.

Q. This is on the bottom of page 35 of your report, that calculation.

A. Yes, sir. Now yesterday we talked about this measure of propensity to methane layering, the thing that I call layering number. I'm on the top of page 36 now of my report. A measure of the tendency to layering given by this concept of layering number. The equation is repeated at the top of this page, near the top of this page. It depends upon air velocity, which we've now established for this rising intake to be 1.34 meters per second. It depends on the width of the entry, six meters. And depends upon the rate of emission of gas at roof level into that entry. And here I'm using my estimated, at this stage, 250 cubic feet per minute of methane. That is .118 cubic meters per second. So we have the three pieces of information for the Southwest 2 rising intake that we require to calculate layering number. Entering those values into that equation gives us a layering number of three. This is a measure of the tendency towards methane layering.

I would now like to refer you to the same table we looked at yesterday, the very last page of the last appendix in my report. Let me remind you again what this table is. This is the table of recommended minimum layering numbers for various roadway inclinations. This is a rising; that is, ascentional airway. It's rising at an inclination of 13 degrees. So if we look along the ascentional row, the middle row of this table, we've got minimum layering number under 10 degrees of 6.2, under 15 degrees of 6.6. So approximately half-way between those two, our 13 degrees. I'm interpolating a minimum layering number of 6.4.

Q. So what we're actually getting on that day is approximately half of the velocity of air flow that would be needed to prevent layering using your perimeters.

A. No, sir, let me correct the statement. We have less than half of the layering number. This does not equate directly to velocity because of the formulation of the equation. This is something we can come back to if you wish.

The point is in this condition, in this scenario, we have a layering number that is significantly below that which will inhibit the formation and the propagation, the streaming of methane layering, methane layer. So it would seem to me that under the conditions that we have specific here that methane layering would be taking place out of Southwest 1 and progressing into the intake stream. Let me repeat that. A methane layer would be issuing from Southwest 1, propagating at roof level along this short length of intake and then continuing to follow the air flow at roof level, propagated now not only by the movement of the air but also the 13 degree inclination upwards. The buoyancy of the gas would help free streaming in addition to air flow induced streaming up that entry.

Q. Let me just jump in for a second and make sure that I'm still on the train or if I fell off going around one of those curves. And I'm going to put this in very simplistic terms, and you tell me if I've got it right. You have taken the average methane flow -- Let me back up. You have taken the air flow measurements that were calculated on May the 8th in the location that you described up the Southwest 2 roadway.

A. Yes.

Q. You have looked at the methane measurements over a

period of time, approximately a month previously?
A. Yes.
Q. And you've averaged them?
A. Yes.
Q. So that the general body of air flow has always had a methane content in it that they have been measuring over that month?
A. Yes.
Q. And those numbers are given ranging from .5, .6, et cetera.
A. Yes.
Q. On each of those days when they measured the general body air flow and got a methane reading. For example, on April the 8th, they had an air flow of 103 cubic feet per minute and an air flow -- methane percent of .5. You're able to calculate the methane flow for that measurement?
A. Yes.
Q. So that on that day we get 518 cubic feet per minute of methane?
A. Yes.
Q. So we average all that up and we assume that on May the 8th that there probably was about 523 cubic feet of methane?
A. Yes.
Q. You're assuming that about half of that is coming

from the old Southwest workings.
A. Yes, for the moment, yes.
Q. And in taking that, you have assumed -- Just a minute now while I get it, about 250 cubic feet per minute.
A. I have assumed 250 cubic feet per minute, yes.
Q. Your assumption is backed up, to some extent, by the calculation you gave me earlier from page 11 of your report where on April the 9th you calculated that the old Southwest district was making at the rate of .246 cubic meters a second.
A. It was April the 2nd, to be precise.
Q. April the 2nd, I'm sorry. So that, in effect, your estimate of one-half coming out of the old Southwest district is corroborated by that earlier calculation, is that right?
A. Well, I've been conservative. I've assumed it was very much less than that.
Q. Yes. This supports you and supports the fact that you're being conservative.
A. Yes, sir.
Q. All right.
A. With one added rider on this to clear up one question, and that is that I have on previous occasions stated that methane emission decays with time from any

standing surfaces. The Southwest 1 was no longer being worked. It was standing, but crushing was still going on. If crushing had not been going on, if the pillars had not been continuously subjected to squeezed pressure, then that methane would have decayed. The fact that the crushing was continuously going on would tend to maintain the methane at a higher level. Now we have no way of knowing which was the dominant factor on here. But from the figures we've looked at, we're looking at on page 35, I would assume that the methane being produced from Southwest 1 was indeed decreasing with time. So my assumption of 250 at this stage for May the 8th, even though it was measured at significantly higher, over 500 on April 2nd, is, I think, a reasonable estimate.

Q. Because on April the 2nd, you calculated the flow at, and I'm going to talk in meters for a second, at .246 cubic meters a second. For the purpose of this calculation, you've used 1. -- Sorry, no, you've used --

A. .118.

Q. .118 cubic meters per second. So a little less than half of what was happening on April 2nd.

A. Yes.

Q. All right, so what we now have is we've got the estimated amount of methane coming out of the Southwest 1, and you've now used that in the calculation you've described to determine if the general body of air was moving at a sufficient velocity to mix that methane and prevent layering. And because the layering number comes out in your calculation at much lower, half of what it should be, that tells us that general body of air flow that was measured on May the 8th was not enough to prevent layering.

A. That is correct.

Q. So the estimated amount of .118 cubic meters per second of methane coming out of that area would layer.

A. I have, in fact, done that calculation, Mr. Merrick. I can quote it to you. This is in old-fashioned units, I'm afraid, but we have indicated there that the air velocity according to the measurements is 1.34 meters per second.

Q. You're on page 36 now.

A. Page 36. I'm going to translate that, and forgive me for this, into old units. That is 268 feet per minute. The velocity was 268 feet per minute. If we take the layering number of 6.4, which would have prevented layering --

Q. Now let me just jump in here and make sure I've got you. The calculation you did a minute ago was using what we actually had.

A. Right.

Q. Checking to see what the layering number was.
A. Right.
Q. It was three. It should have been six.
A. 6.4, yes.
Q. Now you're going to use the layering number that we should have had.
A. Yes.
Q. Run it back through the formula to see what sort of air flow we should have had.
A. Exactly.
Q. To double check your first calculation.
A. Yes.
Q. Thank you.
A. Yes, and doing that calculation, using a layering number of 6.4, gives us a required velocity of 552 feet per minute. That is the velocity we would have required to prevent layering.
Q. Of that amount of methane.
A. Of that amount of methane.
Q. And, I'm sorry, it would have required how much? I've lost it here on the page.
COMMISSIONER 552.
MR. MERRICK And we had?
A. We actually had 268 feet per minute.
Q. All right. Now there is a third way that you've

done a calculation. Or let me back up.

You have also calculated the amount of gas that would be emitted from the Southwest district purely as a result of barometric pressures that day.

A. In the previous section of the report, yes.

Q. Take me to that, if you would. I assume this would be an appropriate time to deal with that?

A. Yes.

COMMISSIONER That would be page 33?

A. Yes, sir.

MR. MERRICK Okay.

A. What has been done and reported in this part of the document is to use the record of barometric pressure recorded at the meteorological station at Caribou Point from May 7th to early in the morning of May 9th, and I have employed the detailed tables in order to produce them in a more visually acceptable form for us. Turning over the page to page 34, we have a graph of the barometric pressure against time.

COMMISSIONER Doctor, could you not have used barometric pressure readings taken at the mine, or would it have made any difference?

A. I was not aware, Mr. Commissioner, of any barometric readings having been taken on a continuous basis at the mine.

COMMISSIONER Oh, I see.
A. There was no such data.
COMMISSIONER There was no -- you say they weren't done or you have no record of them.
A. There was no -- I have not seen any continuous record of barometric pressures measured at the mine.
COMMISSIONER Is that something that would be common in a mine to have that?
A. It is a very prudent precaution and, indeed, is included in some mining legislation, that barometric pressures should be read and noted at the beginning of each shift.
COMMISSIONER Okay.
A. I have not seen that for Westray.
COMMISSIONER Okay, thank you.
A. So returning to the graph of what was happening to the air pressure, the barometric pressure on surface over that 42-hour approximately period, we can see that we have a period of -- Yes, approximately 42 hours, through which there were oscillations; there were variations in the barometric pressure, but the overall trend was downwards.
Yesterday, Mr. Merrick, in response to one of your questions, I described the expansion and/or contraction of air in voidage areas, old workings, bed separations

that is produced by variations in barometric pressure. We can do that calculation.

The calculation is done on page 34, and this is how I obtained the rest of the data. I needed to know the volume of voidage in the old workings. So I scaled one by one each of the entries that had been made in Southwest 1. Each of these entries, each of the crosscuts I scaled off the length. I used cross-sectional areas of 5.5 times 4 for the entries. These numbers are given on the bottom of page 33. And 5.5 by 7 for the areas of pillared workings or extraction. That gave me a total voidage volume of 59,492 cubic meters. This is the voidage, the space, behind those stoppings and in the Southwest 1 workings.

We now have two things. We have the rate of fall of the barometer, and we have the volume of the space in the old workings. As the barometer fell, the volume of gases in that space would expand because of the mechanism we talked about yesterday. The calculation of that expansion is the calculation done just below the graph on page 34. It is a thermodynamic equation, but a fairly simple one. It assumes that the temperature does not change in the Southwest 1. The volume, V-1, is the initial volume, 59,492. P-1 and P-2 are the pressures recorded at the beginning and the end of the falling barometer period, the 42-hour period. And by that calculation, the initial or original volume, multiplied by the ratio of the initial pressure, P-1, and the final pressure, P-2, that gives us the volume to which those gases would expand. That comes out to a new volume of 59,224.

So here we have a situation where the actual volume of voidage space in the old workings is 58,492 cubic meters. The gases in there have expanded to larger than that -- 59,224. The actual space, of course, remains the same inside the old workings. So that excess volume can only result in those gases being pushed out into the ventilated part of the mine. They expand out of the old workings just like air escapes from a balloon when you take off the end.

COMMISSIONER Well, how could they escape if the barometric pressure was the same outside? Wouldn't that equalize?

A. [No audible response]

MR. MERRICK It's the equalization mechanism that you're describing?

A. Yes. It's the transient.

Q. As the pressure drops --

A. It's the transient.

Q. -- outside, the pressure equalizes but it equalizes

by an expansion of the gases?
A. If you take an automobile tire, Mr. Commissioner --
COMMISSIONER Yes.
A. -- at 30 psi, and you open the valve up, the expansion of the air in that tire, because of the decreased pressure, results in that air rushing out. And it will continue to rush out until the pressure inside the tire is the same as the pressure outside the tire. Then the flow will stop. But during that period when the pressure inside the tire is greater than the pressure outside, then there will be a flow of air outwards. That is exactly what is happening here.
COMMISSIONER But I'm -- I want to understand this because it sounds like it's important, and frankly, I don't right at this time. Because if you look here, this is the area from which the equalization would be -- would move out.
A. Yes, sir.
COMMISSIONER Okay. But the barometric pressure would be the same out here as it would be in there, would it not?
A. Eventually at equilibrium. But in order to achieve that equilibrium, a flow of gas has to take place outwards. The pressure inside the sealed off area is greater during this transient period because the outside

atmosphere pressure is going down and this will react.
COMMISSIONER But what is gradually turning on up here? I think I'm getting to you, yeah.
A. This will react.
COMMISSIONER Yeah, okay. So this area here, now because the increased barometric pressure, the increased pressure there has nowhere to go but out here --
A. Yes, sir.
COMMISSIONER -- to equalize?
A. Yes.
COMMISSIONER Okay, fine.
A. And just to make that more precise. We don't have -- we do not have increased pressure in the old workings, what we do have is decreased pressure outside which, of course, has the same effect.
COMMISSIONER Yes, okay. Yeah, yeah. I'm with you now. Yeah.
MR. MERRICK If we start at the point on your graph on May 7th, both inside and outside the mine, we start with this higher barometric pressure?
A. Yes.
Q. As the low moves through, the pressure drops and, of course, the pressure has to drop in the mine?
A. Yes.
Q. The air comes out of the tire?

A. Yes.
Q. Because it expands?
A. Um-hmm. Exactly.
Q. I got you. All right.
A. So if we take the expanded volume, 59,224, compare that with the original volume, 59 -- 58,492, the difference between those two is that amount of gas which has had to be released from the Southwest 1 area flowing into the intake in Southwest 2-B. So taking that change of volume gives us 732 cubic meters. And the equivalent in cubic feet is given there. That is the volume of gas that would be emitted due to expansion during those 42 hours. This has nothing to do with the gas that's actually being made from the coal; this is purely by the expansion of the gases that exist in that voidage.

That is a demonstration of the way the calculation is carried out, Mr. Merrick.

In order to arrive at a more precise value in those hours immediately before the explosion, we'll move on to the bottom quarter of page 34. What I've taken is those last seven hours from 2100 hours on May the 8th to 4:00 a.m. on May the 9th. This is the period of this last fall of barometric pressure. So we're looking at this now to get a more precise value close to the time -- closer to the time of the explosion.

And I repeat that calculation for that shorter time period and that gave a volumetric emission and expansion, and I have this in cubic feet, of 7,475 cubic feet. That is the amount of expanded gases coming out into Southwest 2 over that period of seven hours. So if you take 7,475 cubic feet, looking at the bottom calculation on page 34, 7,475 cubic feet over seven hours, divided by seven hours, divided by 60 minutes in an hour, that gives us 18 cubic feet per minute of gas emission from the Southwest 1 due to expansion effects alone.
Q. And we are assuming that the gas that would be coming out of the Southwest District would be very high concentration methane?
A. Yes, sir.
Q. So what we know is that leaving everything else aside, assuming for the moment that there was no ongoing gas emission from the Southwest District, as you would had assumed in your earlier calculations, and looking solely at the effects of the barometric pressure drop in the seven hours prior to the explosion, there would have been approximately 18 cubic feet a minute coming out of the Southwest District?
A. Yes.
Q. And we know from looking at your calculation minute ago on page 36, that with the air flow, the general body

air flow that was going out Southwest 2-B Road, it was only sufficient to prevent layering of, have I got this right, 26 cubic feet per minute of gas?

A.   Can we back up a little bit because we had not quite reached that stage.

Q.   All right. I'm sorry.

A.   Okay. What we had done was get down to the last -- to the end of the second paragraph, I guess it is, on page 36. We had established that a layering number of three was the condition existing, whereas we needed a layering number of 6.4 in order to inhibit or prevent methane layering.

Backing off. That layering number of "3" you recall was based, among things, on an estimate of 250 cubic feet per minute coming out of Southwest 1. And as you indicated, Mr. Merrick, earlier that would seem to be a reasonable estimate based on earlier observations; nevertheless, it was not a measurement. It was not a measured data point. Therefore, I felt it necessary to go on and examine the effects of that 250 cubic feet minute being some other value.

So the calculation, starting about halfway down page 36, is to that end. What I have said here is -- and this is a similar calculation to the one you refer to on how much velocity do we need to prevent layering. I'm going

to do the same thing now, but instead, I'm going to say let us accept the measured velocity; let us accept the width of the airway; let us assume now a layering number of 6.4 which would have prevented layering and back calculate what the gas flow would be under those circumstances.
Q. What gas flow that could accommodate safely?
A. Exactly. And that is the calculation -- that is the second calculation on page 36. And this gives us a gas flow, "U_g", if layering is not to occur, of 26 cubic feet per minute. This is approximately only one-tenth of the 250 cfm that I estimated earlier. In other words, there's a 10:1 margin of conservatism in my estimate of 250 cubic feet per minute. This does suggest to me that there was a high probability that layering was indeed taking place out of Southwest 1 into the rising intake, Southwest 2-B.
Q. All right. And I guess I was getting ahead of you. If we take the amount of gas flow that the general body of air ventilation that we know existed in those headings on May the 8th could accommodate, we get a figure of two -- 26 cubic feet per minute. Just relating that back for a moment to the rate of gas flow that you've calculated would occur purely as a result of barometric pressure drop, we see that the pressure drop -- and that gave us

18 cubic feet per minute?
A. Yes.
Q. We see that the barometric pressure drop alone would barely have been accommodated by the rate of general body air flow?
A. Yes, sir.
Q. So that even if there was no gas at all coming out, other than through the pressure differential, you'd be close to -- you would just barely, not just barely, but you would be just preventing layering of that gas?
A. You would be in the same order of magnitude, yes.
Q. Okay. Let me just make sure I've got this because I did fall off at one point there, and I'll admit it. You've really come at this three ways. You've estimated the amount of gas coming out of the Southwest district at the 250 cubic feet a minute. You've supported that estimate by the calculation of the rate of gas that was actually being made in the Southwest district using the figures from April the 2nd. Your estimate is conservative comparing it, is that right?
A. Yes.
Q. So using an estimated rate of gas flow, you've run the formula to see what layering number it gave you and it gives you three.
A. Yes.

Q. Significantly lower than it should have?
A. Yes.
Q. Which would tell you that at a gas rate of 250 cubic feet a minute, layering is going to occur?
A. Yes.
Q. Now to double-check that approach, you came at it from the other end. You said knowing the rate of general body air flow in the headings, let's calculate what rate of gas escape could be safely accommodated and mixed?
A. Yes.
Q. In doing that you came up with 26 cubic feet per minute?
A. Yes.
Q. Nothing estimated about that?
A. No.
Q. And that tells you that if, in fact, your estimate of 250 cubic feet a minute is coming out of the Southwest District, no way, Jose, is that going to be prevented from layering?
A. That is my conclusion.
Q. Pardon my loose layman's terminology. So your estimate, the original way you approached it, estimating 250 has got a considerable conservative margin built in there: 10:1?
A. Yes, sir.

Q. And then, just to support that, you've done the calculation as to the amount of gas that would be coming out purely because the pressure drop that day? And that pretty well exhausts the ability of the existing air flow ventilation even if there was nothing else coming out?
A. Yes.
Q. Okay. Let me ask you one other test that you did. You have assumed in each of your calculations to get your layering number, or using your layering number, a dimension of the roadway of, I think you said, six meters by 3.5 meters or something. Now that's a standard measurement that you have from information provided as to the size of these roadways.
A. Yes.
Q. But have you double-checked that with the actual cross-section square feet that have been used on the air flow measurements taken by the mine?
A. We have listed in the air flow measurements, in some of the earlier ones, the actual square footage is quoted. In the later ones we have volume flow and velocity. And if you divide velocity into volume flow, you get the corresponding cross-sectional area. So one can check station by station on the actual cross-sections.
There's one added point I want to make here, and that is the cross sections would and did vary from the

design values, the original driven cross sections, because of roof falls which were then cleaned up, because of additional support -- which would increase the cross-sectional area, obviously. And then the addition of roof supports which would decrease the cross-sectional area because of the actual location of the supports themselves. The actual cross section available for air flow is often not precisely defined, because when additional internal supports are put in after the event in order to help prevent further roof falls or where roof falls have already occurred and the roof is additionally being supported, then there is often space behind and above those additional roof supports. Those are areas in which it is quite difficult, Mr. Merrick, to obtain accurate air volume flow readings because of this difficulty of ascertaining the cross-sectional area.

Q. Generally, though, I take it, that the larger your cross-section, the more significant your numbers would have come out? In other words, it would tend to strengthen the conclusion that there wasn't sufficient volume to prevent layering. The smaller your dimensions, the less strong your conclusions would be because it would tend to increase the velocity.

A. If those smaller dimensions were smaller in the sense of cross-sectional area available for air flow, that is true, but the installation -- let me repeat a point I made before. The installation of additional internal arches or any other kind of rigid support does not necessarily decrease the cross-sectional area available for air flow because of spaces behind and above.

Q. All right. We'll just note that as a qualifier recognizing though to the extent that the roadways were larger because of roof falls, et cetera, it would tend to increase the effect --

A. Yes.

Q. -- as your calculations have done.

A. Yes.

Q. Let me ask you another couple of quick questions on this layer of methane that, in your -- well, let me back up. Based on those calculations and that amount of air flow, and remembering our discussion yesterday about the effect of air -- the general body air flow on the layer of methane and how sometimes it would tend to extend it and other times it would tend to shorten it, what is your opinion as to whether this would be a relatively extended and thick layer of methane?

A. Well, the two factors that primarily control that, given the geometry of the airways, accepting that, is first of all the amount of methane at roof level coming out of the old workings and progressing into Southwest 2-B. And secondly, the inclination of Southwest 2-B at 13 degrees, we have streaming of methane going up for both reasons: both because of the buoyancy of the methane, it would be flowing up there even if there were no air flow at all, and it would be further assisted to flow uphill because the air was also ascential, also going up in that direction -- number one.

Number two -- the fact that we did have air flowing also up that incline would tend to increase the thickness of the layer, as we described yesterday, as we go uphill because of diffusion and particularly eddy diffusion, forgive me for the technical terms; "turbulence," we called it yesterday, along the interface.

Q. All right. So that this layer can extend right up to and possibly enter the heading of Southwest 2-1 Road?

A. That is a possibility, sir.

Q. Now your calculations have told us, or shown us, that the velocity of the general air body would not be sufficient to mix the methane and prevent it from layering?

A. Yes.

Q. I assume though that there would be some mixing mechanism that would occur any time there would be obstructions in that roadway?

A. There would be additional turbulence, yes.
Q. Yes. So, for example, a boom truck parked in an intersection would create turbulence in the general body air flow and might have some degree of mixing effect?
A. The boom truck would certainly have that effect, Mr. Merrick. But additionally, because it was an intersection; because there was a fairly sudden change in the direction of the main air flow coming around here, approximately 145 degrees, because of that sudden change in direction as well as the position of an obstruction like the boom truck, the answer is yes, there would be additional turbulence at that point.
Q. All right. What is your opinion as to whether turbulence points or turbulence factors like that would themselves have been adequate enough to have mixed the methane and overcome the deficiency in the air flow of the general body air?
A. It would certainly have some effect, but perhaps not quite so pronounced as one might imagine. Let me take two scenarios. One in which the methane layer has been progressing for some time and for some distance and has been thickening because of the turbulent mixing. It has come further down into the entry than it would have been at the start of the entry, where the layer is thinner. So if we have a situation, as we may have had at the top

of Southwest 2-B, in the position of the boom truck, that the layer had thickened very considerably by that stage, then in those circumstances, obstructions such as the boom truck and sudden changes in direction would further assist in additional mixing of the air and the methane.

If one comes back, however, and takes the scenario where the methane layer is much thinner, for example, coming out of the -- immediately coming out of the Southwest 1 workings, highly concentrated, very thin, and in that situation we have obstructions or bends, then those obstructions and bends would have a lesser effect on the mixing process, because the methane layer is thinner and more concentrated at roof level.

So one has to look not only at the obstructions and the turbulence caused by them, but also the position and the relative thickness of the methane layer and the concentration of gas in the methane layer at that same location.

COMMISSIONER   Doctor, could I just go a little bit further -- not a little bit further, but another area on that. If you have a thick layer of methane, as you describe, going out and you -- it comes into a turbulent situation, whether it be a boom truck or something, would that not have the effect of the turbulence bringing the high concentration down to an explosive concentration of

methane within that?
A. Yes. The phenomenon of layering occurs because of the fact that the methane gas is considerably lighter than the air. This is why it happens in the first place. Now what is happening as you progress along the layer, and it's getting thicker because of the interfacial mixing, what is happening there, Mr. Commissioner, is that you retain a very high concentration right up at the roof, all the way up, but the gas is mixing more and more along the interface, and you get a broader transient from the general body concentration up to roof level.
Now because of that mixing process that's going along continuously and making the layer get thicker, that means that the gas mixture in that thickening layer is now approaching, approaching, that density of the air, so there is a lesser difference in the densities. And this is why, as the layer gets thicker, it becomes easier for further turbulent mixing to take place.
COMMISSIONER Okay. Yeah.
MR. MERRICK But I assume that if you get a point like a boom truck, it may cause vortexes and swirls that might bring the explosive, that portion of the layer that's the explosive range, may come down or be --
A. The mixing will be enhanced, indeed, as we said earlier. Yes.

Q. All right. And if you had an ignition point somewhere in that vicinity, it might well bring the explosive range down to that ignition point?
A. Yes, sir.
Q. All right. Let me ask you this question: Bearing in mind the calculations you've done, what you've seen in the mine, recognizing that there would be some mixing points or turbulence points such as boom trucks and turns in the roadway, what is your opinion as to the probability on May the 9th, immediately prior to the explosion, of whether there was a layer of methane gas coming up the Southwest 2-B Road and possibly into the Southwest 2-1 Road?
A. I think, Mr. Merrick, that the probability of a methane layer moving from Southwest 1 along this short length of intake and despite the cross-velocity coming in from 3 Crosscut, and then propagating by its own buoyancy as well as by the air motion up Southwest 2-B, I think the probability of a methane layer existing there was fairly high.
The extent to which that methane layer continued, if, indeed, it did continue to the point of the boom truck that we've just been talking about, there would, as you have correctly stated, been additional turbulence and therefore additional mixing at that point. Whether the

methane layer was able to maintain sufficient of its integrity to continue up the slope into the ends of the headings itself, certainly the inclination was there to cause that to happen, we shall not know.

The probability -- the possibility is certainly there. Whether, in fact, it did happen or whether the turbulence generated in this region was sufficient to break up that layer, I doubt if any of us will ever know.

If one turns to the Southwest 2-1 Road, this was level or near level. The roof was actually inclined laterally because of the inclination of the seam. But in this direction it is approximately on strike; that is, approximately level. Therefore, if methane layering had continued, it would be more probable to continue straight up, because of the inclination, into the left-hand, if I can use that word, part that is continuing straight up Southwest 2-B. It's more probable it continued straight up than turning to the right and progressing along Southwest 2-1 Road. I am not saying that that could not have happened; it could well have happened. But we simply do not know.

Q. All right. Noon break?

COMMISSIONER Yeah. We'll recess until 2:00. Thank you.

INQUIRY RECESSED (TIME: 12:35 p.m.)

INQUIRY RESUMES (TIME: 2:04 p.m.)

COMMISSIONER Mr. Merrick?

MR. MERRICK Thank you.

Q. Dr. Salamon [sic], just before the noon break, we had been talking about your opinion on methane layering in the Southwest 2-B Road. You had done the calculation for us earlier in the morning that indicated the layering number that that body of air would give. It was a layering number of three. To what extent can that layering number be an indicator of the tendency of the methane to layer and extend? In other words, the fact that you've got a layering number of three, does that give us any indication at all of the tendency of that volume of air to layer and extend the layer of methane?

A. Yes, it does. The original work that is the classic paper by Baake & Leach that I referred to yesterday and on which this type of calculation has been based from then until the present time, this past 25 years or so, that original and classical work did, in fact, plot the layering numbers against length of layer; and, secondly, concentrations at roof level along that layer. It would be inadvisable to use those actual plots for conditions other than those in which those experiments were done. Those were particular sizes and particular inclinations of experimental on-surface wind tunnels, airways. So one should not use those specific distances and specific concentrations measured in those experiments as being uniformly applicable.

What we can say is that as the layering number decreases below the recommended minimum value, then the methane layer that would then form and exist would both be longer, the lower the number, and also the concentrations at roof level would maintain high for a greater distance.

Q. All right, so we can give some significance to that layering number of three in supporting an opinion as to a layer in that roadway and the fact that it may well have extended up some distance into that roadway.

A. Yes.

Q. All right. Now we talked just before the noon break about whether your opinion as to the likelihood of that layer turning the corner on the Southwest 2-1 Road or continuing, in fact, up the heading of the Southwest 2-B Road, and you indicated that it was much harder to draw that conclusion past that junction point of the crosscut. How difficult would it be -- my question to you, I guess, is this: well, what if we were to take measurements in the Southwest 2-1 Road, just as you did in the Southwest 2-B Road, calculate the volume of air moving, the make of gas, and determine whether or not there would be a layering number of an indicator of the layering that might occur on the Southwest 2-1 Road up in the heading. Are there additional difficulties if we were to attempt to do that type of calculation in that particular heading?

A. I'd like to refer you to the definition of the layering number again, and if you've got this same page in front of us, page 36. You recall that the layering number is calculated on the basis of velocity, width of entry, and emission of gas in its concentrated form. Within the headings, we certainly have an indication of the velocity, that very low velocity, that pertained within those headings. We know that the width of the headings. What is extremely uncertain and very difficult, would be very difficult to put a number on, is the value of Q_g, because this is not simply the total amount of methane being produced in the heading, it is that amount of method that reaches the roof in concentrated form and, therefore, is able to form a layer. Now that would be a number which would be extremely difficult to estimate.

This is one of the reasons we referred to yesterday why in situations like that the guideline, in the case of the United States, the mandated methodology, is simply to quote a minimum value of air velocity.

Q. All right. So that's why you have not tried to do that same calculation in the heading?
A. That is correct.
Q. Let me ask you one more question dealing with this layering of gas that you've expressed an opinion on coming up the Southwest 2-B Road. What effect would there be if that road had cavities in the roof caused by falls or other situations?
A. Mr. Merrick, I wonder if I could refer you to Exhibit 37-B, page 225.
Q. Yes.
A. These are measurements taken and reported in --
COMMISSIONER One second, please. I haven't been able to locate that yet. Okay, 37-B, at what page?
DR. MCPHERSON Page 225.
COMMISSIONER Okay, thank you, I have it.
DR. MCPHERSON This is a paper written by a gentleman called E. J. Raine, who was an inspector of mines in the United Kingdom at the time he wrote this paper. It is a paper on methane layering and, specifically, practical measurements taken of methane layers. I asked you to refer to this page specifically. The geometry is not the same as the Southwest 2-B roadway, but it does show a roadway in which the roof is considerably disturbed by roof cavities. There have been roof falls. And we can

see the effect of those roof cavities, that is, that they fill up with methane, but those roof cavities, nevertheless, do not prevent the layer from forming or being maintained. Indeed, this is an even more dangerous situation because we then have a methane layer which connects bodies in those cavities, bodies of methane, therefore, increasing the total volume of methane available to take part in a flame propagation above that that would exist purely in the layer and if there were no roof cavities.

Q. In fact, I look at the diagram that he uses there, and we're not suggesting that it's exactly analogous, but in the measurements that he took, you might get a methane in the general body of air of .2 percent as it goes up. You might get methane percentages, if I'm reading this correctly, of, say, .04 or .12 or 1.8 in that thin layer. But in the pockets themselves, you're getting very high readings.

A. Yes, sir.

Q. Up as high as 78 percent, 60 percent, 50 percent, 55, et cetera. So that's quite a mass of methane that if an ignition should occur with the mixing motion that takes place with an explosion or an ignition, that would be a tremendous body of gas available to be mixed into the explosive concentrations.

A. Indeed.
Q. All right. And my last point on this, and I think this is sort of addressing it, I assume that merely because there are cavities in the roof does not necessarily increase or take the place of the mixing motion that velocity normally should have.
A. There are two factors here, one we've already referred to and that is that those roof cavities provide additional accumulations of gas. The second effect is that the presence of those roof cavities indicates that the roof was not a smooth surface. The roof is never a smooth surface, but in situations like that it is even rougher than normal. If there is a sufficiently high velocity to create turbulence, mixing turbulence of the type we referred to and we have an undulating or very rough roof condition, then the turbulence caused by that rough roof would be enhanced. Rough sides, rough surfaces, increased turbulence, is why we have fins on radiators to do exactly the same thing. That is in a condition of normal air flow through an airway duct, whatever.
Where we have a methane layer in existence, I would like you to look at 37-B, page 220. Do you have that?
Q. Yes.
A. This is from the same paper by Mr. Raine that we

just referred to, and Diagram D, bottom right-hand corner, shows a methane layer in shaded region with the concentrations of methane at varying horizons through that layer. And underneath that shaded region showing the methane are dotted lines, these representing velocity contours. So each dotted line represents an envelope of velocity. The point I wish to make here, Mr. Merrick, is that up in the methane layer, the air movement, the air velocity and the turbulence which would normally be associated with it is confined below the layer. So roughnesses in the roof within the layer are going to have little effect on additional turbulent mixing.

Q. In effect, is it fair to say that the methane layer fills in the roughnesses and, in effect, smoothes it out for the layer to continue to stream upward?

A. It is sometimes being referred to as a lubricating effect for the air. The air slides underneath it.

Q. A lubricating effect. All right, thank you. Now we, therefore, have, in your opinion, a layer of methane coming up in the road in the time immediately prior to the May 9th explosion.

Let me talk just for a few minutes about coal dust, and then we'll get to your views on the mechanism of the explosion itself. We've heard evidence about the methods of dusting and stone dusting coal dust. I won't get you to describe for us how that's done because I think we've had some background evidence on that. But I would ask you this: How adequate is it if one were to put down a layer of stone dust, how important is it to have your stone dusting completely mixed with the coal dust?

A. It is, indeed, important that that mixing should take place. A layer of coal dust sufficiently thick to be visible; that is, a very thin layer of coal dust, even if it has been deposited on underlying stone dust/coal dust mixtures, even that thin layer, visible, thin layer of black coal dust, would be sufficient to, if raised into the air, would be sufficient to propagate a coal dust explosion.

Q. What you're suggesting to me, and correct me if I'm wrong, is that even if you stone dust today, if you're continuing to make coal dust or coal dust continues to settle out, that may not be adequate tomorrow.

A. Exactly. And this is particularly pertinent where you have coal transportation systems at Westray along the belt lines.

Q. And those are areas we've already heard are particular dust collection points, I guess, they can be called.

Let me direct, if I can find my correct reference here, to the Manager's Safe Practice Rules. They are in

37-A and, in particular, at page 123. That purports to be the rock dusting procedures set out by Westray management?
A. Yes.
Q. I'll just ask you to comment on those rules and the adequacy of those rules?
A. They are a reflection of the Nova Scotia Coal Mine Regulations with respect to the concentrations of incombustible, therefore, combustible dust in mine airways, coal mine airways. So they are an accurate reflection of the law.
Q. And I assume that if they were to be correctly and religiously followed, that, in your opinion, would they be an adequate set of rules for stone dusting?
A. With one added proviso that seems not to be included in the Act, and that is that the application of stone dust should be done at regular intervals of time. The relevance of that additional comment is that a sample that is taken by scraping into or digging into deposited dust may be looking at dust that has been deposited last week, last month. Whereas it is the most recently deposited dust that is the dangerous or if mixed with stone dust, not a dangerous mixture.
Q. Okay. Let's talk about the testing or the sampling process and in your report you, in fact, refer to two

sets of samples that were taken prior to the explosion. The sampling such as is referred to in your report, the purpose of that, I take it, is to determine the amount of incombustibles mixed with the coal dust?
A. Yes, in my report, I have used the combustible percentage.
Q. And you also describe in your report the physical mechanism by which the addition of stone dust inhibits coal dust explosions, sort of, in effect, providing a filler between coal dust particles and also being a damp or absorbs the heat. And we won't need that, but let's talk about the testing procedures themselves, the results of which you report on. Tell me briefly the testing mechanism once you have a sample.
A. Again, let me use the board on this one. The powdered sample of dust, the mixture of whatever those dusts are, is placed in a small crucible, a small weight, a few grams, and that crucible is heated at -- various testing laboratories have a somewhat different procedures. In Nova Scotia law, it is specified that the initial heating be done at 212 degrees Fahrenheit. That is 100 degrees Centigrade. And the purpose of that is to drive off the moisture. The sample is weighed before and after, and the difference in the weight is clearly the amount of moisture that has been driven off. That is

expressed as a percentage of the weight of the original sample and, therefore, we have a percentage weight of moisture driven off.

The Westray samples were of the order of three percent moisture. There are variations, but they were of that order.

The second process is to take that now dried sample, the same sample, but it's now dried, and to heat it to a greater temperature, normally, somewhere between 500 and 800, 900 degrees Centigrade. Again, different laboratories have their different procedures, their different temperatures. This brings the crucible and its contents to a dull red heat, a bright red heat, depending where you are on this scale of temperature. And that burns off anything that is readily oxidized. This burns off, specifically, the coal dust. So we're then left with the crucible with just the small amount of ash left in there. The difference in weight between stages 2 and 3 is the weight of the coal that has been burned off and no longer exists in the sample. That is the percentage when expressed as a percentage of the original, that is, the percentage of combustibles in the sample. We're then with the weight of the inert material, sometimes referred to as simply the ash content.

So we have three numbers. We have the moisture

content. We have the combustibles, and we have the final ash or inert. Very often these two, the moisture and the ash, are added together and referred to as the incombustible content. So when we, as we usually do, refer to the combustible and the incombustible, adding together to make 100 percent, the combustible is this part; the incombustibles are these two added together.
Q. So moisture is to be taken into account in determining the ratio of incombustibles?
A. Yes, sir.
Q. All right. Now we see in the test literature that there is both a high temperature and a low temperature method of doing this. What's meant by that?
A. It's referring to the choice of temperature in this range. The argument, and I have seen this continued to be debated, the argument is that at the low end of this temperature range, the coal dust will be burned off, and the limestone dust, which is the stone dust, will be unaffected.
As you continue to increase this temperature, and in that situation that would be referred to as the low temperature test. At higher temperatures, there is the possibility, and this is where argument still exists, there is a possibility that some of the limestone dust will be dissociated, chemically disassociated, and some

of the carbon dioxide from that stone dust will be driven off; therefore, giving a small but measurable additional loss of weight. So one would normally expect to see small differences between the low temperature burning of combustibles and the higher temperature burning of combustibles. This is why we refer to the low temperature or high temperature test.

Q. And, therefore, we should expect to see the difference, for example, the high temperature test tending to give a slightly lower ratio of incombustibles to combustibles?

A. Yes.

Q. A lesser amount of incombustibles in ratio to the combustibles?

A. Yes.

Q. Now this is where I'm going to get you to patiently take us through the two tables that you have set out on your report at page 19. And, as I understand it, Dr. McPherson, what you have done is you have looked at the -- There were two sets of samples taken. One was on April the 29th, 1992, one was on May the 8th, 1992. And you describe in your report at page 19, basically, where these samples -- how they were handled and where they were sent.

The first set, April the 29th, 1992, were analyzed at one lab.

The second set, the ones taken on May the 8th, the day prior to the explosion, were divided up into four amounts and sampled at four separate labs. And I will state for the record and by way of explanation to you, that that occurred at that time because at the time the samples were analyzed, the explosion had occurred. There were various parties to the various investigations already in existence, and to ensure that everybody had their own coal dust sample to analyze, each one was given one quarter. The RCMP were given a portion; the Inquiry was given a portion; the Department of Labour was given a portion; and I for -- I guess the mine was given a portion; thus, the reason for four separate laboratories performing analyses on the one set of samples.

Now as I understand it, your tables on page 19 are your compilation of the test results. And you have set them out in this way to make it easy for us to see the comparison between the various tests that were carried out, is that correct?

A. Yes.

Q. All right. What I would like you now to do is take me to the test result documents themselves as they appear in the exhibit and show us the test results that you're referring to and correlate them to the numbers that are

contained in your report. And can we start with the ones taken on April the 29th.
A. [No audible response]
Q. If that's convenient.
A. That's fine. Table 5.1, in that case, we're looking at. These are the four samples taken at the locations indicated in that table, specifically, No. 2 Slope outbye 9 Crosscut on the floor and the rib. Southwest A Road inbye 1 Crosscut floor and grid.
Q. Just to help me. Locate that on the map for me.
A. No. 2 Slope outbye Crosscut 9. No. 2 Slope outbye Crosscut 9. No. 2 Slope is the conveyor slope. This is Crosscut 9.
Q. Yes, all right.
A. And the other one was Southwest A Road inbye 1 Crosscut. Southwest 1. Where is Southwest 1?
Q. You may find it easier on that map above which is the larger diagram. Larger scale.
A. I'm looking at the wrong thing anyway. It's Southwest A Road. Yes.
COMMISSIONER Southwest A Road or Southwest 1?
A. I have denoted as Southwest A Road, Commissioner.
COMMISSIONER Okay.
MR. MERRICK There is a Southwest 2-A Road.
A. Yes, that is probably the one because we have a

Crosscut 1 which is this one. So the position seems to have been right there.
Q. All right. Okay.
A. I'd like you to turn to Exhibit 37-A, page 190.
COMMISSIONER 37-A.
MR. MERRICK Just for information purposes, page 188, that exhibit apparently has a memo --
A. Um-hmm.
Q. -- that describes the taking of the samples themselves and the sampling of it. All right. For those who want to have a little background of that, that document is there. Okay, we're at page 190.
A. The four samples are listed there. Let us take the first of them. This is showing an ash content of 23.76. The moisture content, number one part on the board here, was not measured for any of these samples. And the memo that you referred to on page 188 reflects that missing moisture content.
Q. And if we look at that memo, we'll notice that, first, the samples apparently were not analyzed for a period of time --
A. Yes.
Q. -- and then there was no attempt made to measure the moisture, so comments are made that the results may be skewered a little bit by not having the moisture content.

All right.
A. That is correct. So we have --
Q. What --
A. We have a missing moisture content and the 23.76 is this final part only.
Q. Yes.
A. I have assumed the moisture content, Mr. Merrick, based on the moisture contents that were actually measured on the samples referred to lower down the page.
Q. All right.
A. And on the basis of that guidance from those other samples, I've assumed a moisture content of three per cent. All of my tables report these results in terms of combustible, because this is the sense in which the law is written with respect to combustibles rather than incombustibles. The difference is simply taking one number away from 100.

So let us take, for example, the first sample reported on page 190, 23.76 percentage of ash. I've added to that three per cent moisture, making 26.76 per cent incombustibles, giving me 26.76 incombustibles. The remainder is therefore the combustible part. So if we take 100 minus 26.76, we arrive at 73.24 per cent combustible content. And that is the first number given in my table.

Q. And you've just rounded it down?
A. Yes, sir. To the nearest whole number.
Q. And you've done that with each of the next three?
A. I've done that with each of the next three and the calculation has been the same. I would ask the Commission to make one alteration to my table there, the bottom number. The 67 per cent. In checking these numbers, that should actually be 64 per cent.
Q. Okay. So we take out at the 67 and put in 64. One other thing we should note is that in setting out the numbers that you have in your table, you haven't quite set them out in the same order that the test results appear on page 190.
A. That is correct. Yes, I have not.
Q. And following your guide, if I can suggest that on page 190 we look at each of those test results and number them 1, 2, 3, 4, and then if we number the test results as shown on your report, they should be 1, 4, 3, 2, is that right?
A. That is correct.
COMMISSIONER That's the first table?
MR. MERRICK The first table.
COMMISSIONER 1, 4, 3, 2.
MR. MERRICK And that way we can then compare them correctly. All right.

A. Thank you.
Q. Now the bottom line conclusion, accepting for a moment that we've made that three per cent moisture adjustment, is that the com -- well, let me ask you: What is your conclusion as to what these test results -- these samples taken on April the 29th indicate as to the adequacy of stone dusting where the samples were taken?
A. Well, the regulations require that the combustible content be not more than 35 per cent in the absence of methane. And if methane is present, then that combustible content is reduced even further. That allowable combustible content is reduced even further. But let us hold to the 35 per cent, assuming there's no methane present. We can see that the combustible contents reflected in these samples are very considerably greater than 35 per cent, and in two cases, approximately double the legal allowable limit.
Q. All right. Let me take you to the second set of tests that were conducted on samples taken on May the 8th. Now this is going to get just a little more confusing, so we'll go through it slowly. If you can show us, in the exhibit book, each set of tests and correlate it to your tables -- just before you do, on your table itself is there one other number that should be corrected there or numbers that should be corrected

before we start going through our analysis?

A. There are indeed. Let me say that because of the procedure that was used, Mr. Merrick, of dividing this sample into components for each of the interested parties and each of those parties sending them off to laboratories of their own choice, what we have in the exhibits is a somewhat confusing series of reports from these various laboratories. They all report in different ways. They all have slightly different methodologies. And, indeed, in two cases reports came back on the same samples, including the same results, but in a different letter format and these appear as different exhibits even though they are referring to the same samples. The whole thing was very confusing, and I would ask the Commission to bear with me while we go through this.

Q. All right. First, should we make a correction on that table?

A. I would like to make two corrections. First of all, the -- let me first describe the table, Mr. Merrick.

Q. All right.

A. There are four samples, and we're looking across the top of the table now. The four samples are given by name. One Main outbye 10 Crosscut. This is in No. 1 Slope. DS-3. Dust Station 3. "F" for floor.

And the second numerical column is the same location but the sample taken on the side, the rib.

The third column is 3 North Main outbye 2 East. Dust Station 4. "F" for floor sample.

And the last one is the same location but with the sample taken on the sides. The rib.

Q. Can I -- can we assume that because they are now referring -- these locations would have come from Westray themselves? Dust Station 3 and Dust Station 4.

A. Yes.

Q. I assume that indicates that they were, in fact, beginning to establish a more regularized dust sampling program?

A. Just as they had ventilation stations, just as they had monitoring stations, they also had dust measuring stations.

Q. All right. Okay.

A. Okay. And down the -- I think the other two columns on the left-hand side are self-explanatory. One refers to the laboratory where the sampling was done, and the second one is the date.

Q. Now we've got five laboratories, but two of those are the same: the TSRE are the one laboratory, I take it?

A. Yes, sir.

Q. Okay. Thank you.

A. Now let me make the corr -- having identified what

the columns are, let me make the corrections I would ask you to make. First of all on the first numerical row, that is, Lab CRE, there are numbers given under the low temperature heading in each of the four columns. The first is 42.8. Do you have that?
Q. Yes.
A. The second is 39.9. Reading across to low temperature. Third is 68 and the fourth is 65.1. I would ask you to erase those four numbers. The reason that they were in there was because of the confusion I've already spoken to. This is one of the laboratories that reported twice, and this resulted in a confusion of these numbers.
Q. All right.
A. The second correction I would ask you to make is on the row underneath. CBDC Laboratory. Yes?
Q. Yeah. Got it.
A. Read across to the 35.5.
Q. Yes. That's under the --
A. "Low temperature."
Q. -- rib? Yeah, got it.
A. Yes. That should be 32.5. I apologize for that. That was a straight typographical error.
Q. Okay.
A. Now because of the four numbers that we eliminated,

that has changed the average, the bottom row, for the relevant columns. Reading across, the 42.3 becomes 42.1.

Q. Yeah.

A. The 35.9 becomes 34.9. Yes?

Q. Um-hmm.

A. The 67.4 becomes 67.2. And the last one, 64 becomes 63.7.

Q. All right.

A. I ask your forbearance for making these corrections. They are -- they do not alter, at all, the conclusions. The averages have changed very little at all. But we have made those corrections for the purposes of accuracy of the record.

Q. Okay.

A. Okay. Now let us take each of those rows one by one. Let's take a look at the CRE Laboratory samples. And I would ask you to turn to page 201 in 37-A.

Q. Okay. Got it.

A. We have four samples reflected on that page. The last column is the combustible matter. And if you care to read across my row for CRE on my Table 5.2, you will see that these do indeed correlate with the numbers given on the exhibit.

Q. Again, your order is slightly different than theirs, but the numbers are all sourced there?

A. We shall find this all the way through, Mr. Merrick, because of --

Q. All right.

A. -- the various ways in which these things were reported to us.

Q. To put them in the table you had to use a common format? Okay.

A. Yes, sir.

Q. All right. So that answers your numbers on CRE?

A. Yes.

Q. Okay.

A. The Cape Breton Development Corporation numbers, in the next row. I would ask you to turn to page 198.

Q. Got it.

A. And, again, we're looking at the last column on this page. Let's take the first pair of numbers. These were two tests done on one of the samples, "DS-3 R." And the reported combustibles: 32.48 and 32.59. I've taken the average of those: 32.54. And this is where the 32.5, one of those that we altered, appears on my table.

Q. All right, I follow you. And, again, you've rounded it down to the one --

A. First --

Q. -- decimal place?

A. Yes, sir.

Q. Okay.
A. And the --
COMMISSIONER Where does that appear? On Table 5.2, is it?
A. Yes, sir.
COMMISSIONER And we're looking for?
A. CBCD.
COMMISSIONER Yeah, okay.
A. Under "low temperature." Second numerical column along.
COMMISSIONER Oh, that's 38.5. The one we just changed?
A. 32.5.
COMMISSIONER 32.5. I'm sorry. Yeah.
A. Yes, sir.
COMMISSIONER Okay.
MR. MERRICK Because that's the sample that they identify on page 198 as being the DS-3 R. Dust Station 3 Rib. And they did the two readings and you've averaged them?
A. Yes.
Q. All right. And I take it we can do the same for each of their -- they've done two readings on each of the location samples. DS-4 R. They've got the two readings: 62.32 and 62.18. You've averaged them. DS-4 R at 62.2?
A. Yes, sir.

Q. All right. So that takes us across that row.
A. "TSRE," the first row referring to TSRE. Please turn to page 205. And we have two samples analyzed and reported on this page. The first is DS-3 roof.
Q. That's right in the middle of the page?
A. Right in the middle of the page. And the mean percentage incombustibles you'll note is 56.1. That is incombustible. So to get the combustible, 100 minus 56.1 is 43.9, and that is where the 43.9 comes from on my table.
Q. So they reported on that one location sample, but they reported on both a high temperature and a low temperature test?
A. Yes, sir.
Q. I follow you. And the second result that they show down there on the same sample is for the low temperature test?
A. Yes.
Q. And you've taken their reporting on the combustible.
A. They're reporting 64.9 incombustible.
Q. Incombustible.
A. So subtract that from 100 and you get 35.1 combustible content.
Q. Okay. Got it.
A. Let me point out that this same data is given on

page 221 of this exhibit. There's no need for us to go through that; it is the same data. I point it out to prevent any further confusion. It is -- page 221 is not a separate sample, it's the same data.
Q. Got it. All right.
A. That brings us down to Lab Canada. Those results are reported on page 218. Tests done by the Government of Canada. The four samples have been -- each of them has been analyzed three times. Let us look at the larger table on this page and the first group of three numbers. These are the three analyses of sample DS-4 R. Yes?
Q. Under "Crucible 10, 11, and 12"? Yes.
A. Yes, sir.
Q. Okay.
A. Again, look at the final column and, again, they are reporting total inert; that is, total incombustibles. I've taken the average of those three numbers, 36.12, 36.23 and 36.78. The average is 36.34. Subtract that from 100, gives us 63.6 combustibles. And this is where the 63.6, under that appropriate column, in my table comes from.
Q. Yeah, because those three were identified as samples taken from DS -- Dust Station 4 R?
A. Yes, sir.
Q. All right. And I take it you've done the same thing

then for each of the other three location samples?
A. Yes.
Q. All right. Take me to the last TSRE.
A. The last one is another TSRE. And this is reported on Exhibit -- page 202.
MR. MERRICK Yeah.
A. Bottom of the -- bottom third of the page gives two tables: one referred to as "Table A" and "Table B." Do you have those?
Q. Yes.
A. Table A refers to the high temperature tests. Table B, to the low temperature test. Under Table A, there is a row of the mean incombustibles. The first number if 56.1. This is DS-3 Floor.
Q. Yes.
A. Again, subtracting that from 100 gives us 43.9. That is the 43.9, the first number, shown in that row on my table.
Q. Okay.
A. The other seven numbers are obtained in the same way.
Q. All right.
A. I'd also point out, Mr. Merrick, that this same data is repeated on page 220. And, again, I point that out to prevent any, hopefully, further confusion.

Q. All right.
A. The samples reported on 220 are the same samples, the same results that we just looked at.
Q. And, again, by looking at both Tables A and B, we can then fill in the numbers across for both high temperature and low temperature samples?
A. Yes.
Q. And, again, looking at the sample results, what conclusions can we draw as to the adequacy of stone dusting in the areas where those samples were taken on the times when those samples were taken?
A. Again, let us remind ourselves that the legal limits for combustibles, even in the absence of methane, is 35 per cent. We can see that the majority of the samples are above that legal limit. And in particular, the samples taken in the North Main are, again, approaching twice the legal limit. This does tend to indicate that at least in the North there was very little, if any, stone dusting being carried out.
Q. I'm going to ask your general opinion on this in a minute, but just before I do, you make a comment on the very bottom of page 19 that I think is significant; where you refer to the ash content of Westray coal. And I assume what you're talking about there is that the coal itself, without the addition of stone dusting, has a

certain ash content?
A. Yes.
Q. You have been advised by Professor Amyotte and you have also been informed of a statement which has been attributed to Mr. Phillips -- let me start with Amyotte. That Amyotte has reported that the inherent ash content of Westray coal was 20 to 30 per cent on its own.
A. Yes.
Q. And that Mr. Phillips has made the comment that Westray ash [sic] has contents in the range of 25 to 50 per cent.
A. Yes.
Q. In your testing procedure that you described, I take it that the amount of incombustibles that you would be left with would include this inherent ash content that was in the coal to begin with?
A. Yes.
Q. So that when we look at the amount of incombustibles that are left, only some of that has come from the coal and only some of it, the remainder of it, may have come from stone dusting?
A. That is correct.
Q. So I take it what that tells us is that when we look at these numbers, when we see that the incombustible content was below where it should have been, we can draw

the conclusion that stone dusting didn't even account for that amount of incombustible?

A. Right.

Q. Stone dusting would have accounted for even a lesser amount?

A. Indeed, yes.

Q. So that there is -- all right.

COMMISSIONER So if the amount of incombustibles was, let's say, 40 percent, as shown on the table, and we subtract from that the 30 percent ash, then the stone dusting would have amounted to just 10 percent?

A. Exactly.

MR. MERRICK I take it with this one qualification, if it's 20 percent ash in the coal, that's 20 percent of the coal. So it's not a straight percentage conversion. Do you follow me?

A. No.

Q. Maybe it is. I've got to stop letting my physics 100 keep popping up here. If 20 percent of your coal is ash, and if you take a sample that does, in fact, have some stone dust in it, the ash content of the coal will not be 20 percent of your sample. It's only 20 percent of the coal. Do you follow me? Don't let me bog us down.

A. Let me give you a specific example. Let's put numbers to it to illustrate what I think your point is. If we took a sample that indicated 70 percent combustibles, 70 percent coal, let's call it coal, and 30 percent incombustibles, if we got that result from a sample and the coal seam from which that coal dust has originated, itself, contained 20 percent ash, following the Commissioner's example here, this would mean that we have 70 percent coal, 20 percent ash from the original coal seam. That only leaves 10 percent of the incombustibles that could have come from stone dust.

Q. All right, I'll stay out of the way. Bearing that in mind and taking that adjustment into account and looking at these figures, give me your opinion as to the adequacy of stone dusting that was occurring in this mine as reflected in these samples?

A. Well, it was clearly inadequate, Mr. Merrick. In the one main, this is the main slope intake that has not been subjected to coal dust from a conveyor or from workings, this is intake air before it reaches any of the workings or reaches any conveyor, one would expect the combustible content there to be, indeed, pretty low. And, indeed, it is lower than in the North samples. But, nevertheless, it is still above the legal limit in those floor samples. I'm looking at the averages, 42.1 and is just on the legal limits, 34.9 as against 35 for the rib samples. That is in the main intake.

And, of course, I'm repeating myself here but when we look at the North Main, we are well over approaching maybe twice the legal limits of 35 percent. So the conclusion is inescapable, that there was very little, if any, stone dusting being carried out in the North.

Q. All right. Your general opinion, Dr. McPherson, assuming that to be the case, I take it that stone dusting normally lightens the colour of the coal or lightens the colour of the coal dust.

A. Yes.

Q. If, in fact, there was as little stone dusting taking place as these test results indicate, I assume that would be visibly obvious in the sense that you'd be looking at very dark coal dust as opposed to a light grey coal dust that should be the appearance with adequate stone dusting?

A. Yes.

Q. So that visibly it should have been readily apparent whether there was adequate -- It should have been readily apparent that this little stone dusting was taking place.

A. Yes, indeed. One of the side advantages of stone dusting, quite apart from its major purpose of helping to suppress coal dust explosions, is that it does improve visibility in the mine because it gives a greater reflectance to light from miners' cap lamps and other light sources.

Q. You refer in your report, I believe, to the fact that there were orders given to Westray by the Department of Labour relating to stone dusting.

A. Yes, sir.

Q. I'm going to ask you to turn to Exhibit 37-A at page 227. The first two pages are inspection report forms and are dated April the 29th, 1992, and they will speak for themselves. The last two pages are order forms, again dated the same date and apparently as a result of the visit that's referred to in the inspection reports. On those two pages, pages 229 and 230, I see that four separate orders were made dealing with dusting, and as we look at the body of the order forms, just below there we see the time period in which they were to be carried out. Orders 1 and 2 were to be carried out immediately. Orders 3 and 4 were to be carried out on or before May 15th. Orders 1 and 2, we can read for ourselves. I'm not going to suggest that these were the only communications that took place between the Department and the mine relating to dusting, and we will follow up with others, the giving of these orders and the reaction to these orders, but these are the orders that you, I think, referred to briefly in your report.

A. These are the orders I refer to on page 20, yes.

Q. All right, I won't ask you any further comments about those. Others can speak to them in more detail.

Now I want to come to your opinion as to the explosion and how it occurred and propagated. Maybe this would be, if we're going to break, this would be an appropriate time to break.

COMMISSIONER Okay, we'll take 10 minutes then, sure.

INQUIRY RECESSES (TIME: 3:08 p.m.)

INQUIRY RESUMES (TIME: 3:22 p.m.)

COMMISSIONER Okay, Mr. Merrick?

MR. MERRICK Dr. McPherson, in your report, you describe in your opinion how the explosion of May the 9th initiated and propagated through the mine. I would ask you perhaps to just take us through it in your verbal evidence. Based on all the information that we've gotten out on the table to date, what is your opinion as to how that mine exploded?

A. I'm going to refer to Section 9 in my report, Mr. Merrick, and I think the best answer I can give to your question is to talk through that section of the report.

As an overview statement, before getting to any details, the probable scenario is that there was an initial ignition of methane gas which in turn communicated its flame to larger accumulations of gas, sufficiently large and sufficiently well mixed with the air such that they were in the explosive range as to produce a methane gas explosion. As so often has happened in the past, that methane gas explosion provided the sufficient amount of energy to initiate a coal dust explosion. That coal dust explosion then propagated throughout most of the mine. Now let me come to some of the details to fill in that skeleton.

It is my opinion that the most probable location of the initial ignition was in the Southwest 2 area. The question that is always asked in any mine explosion investigation is: What was the actual cause of the ignition? In some investigations, the cause is obvious and clear. In many, there is considerable doubt on the actual ignition point or the actual cause of the ignition and we're left with being able to do little better than to list the probable sources of ignition. And that is the case, I would submit, at Westray. It is doubtful if any of us will ever know with absolute certainty where the initial ignition occurred. So we are left with looking at the probable sources.

To my mind, there would seem to be three such sources. First of all, the continuous miner in heading Southwest 2-1. Secondly, the boom truck at the junction of Southwest 2-1 and Southwest 2-B. And, thirdly, the roof bolter in the left heading of Southwest 2-1.

In September, 1992, the Royal Canadian Mounted Police organized and conducted examinations of the Southwest 2 area and during those examinations, it was found that all three of these machines were running at the time.

Now let us consider each of these three sources in turn. First of all, the continuous miner. If the source of the initial ignition was the continuous miner, then the most probable cause of that ignition from the miner would be frictional sparking at the pick points. Now the mechanism of a frictional ignition at a mining machine is not altogether simple. Sparking and the appearance of sparks is quite common on continuous miners, shearers and other types of mineral-winning equipment. Those sparks may not individually have sufficient energy to ignite a methane air mixture and such sparking is not at all unusual. Virtually any machine operator, I'm referring to coal-winning machines here, will say that sparking at the pick points is a fairly common occurrence. Few of those sparks result, very few of those sparks, result in frictional ignitions. And, indeed, laboratory tests have shown that such sparks individually seldom have sufficient intrinsic energy to ignite a methane air mixture.

So how do frictional ignitions actually occur at the pick points of continuous miners and other types of coal-winning machines? This is the mechanism: If the picks or an individual pick cuts into a material, a non-coal material that is of sufficient hardness, sufficient strength, is abrasive and has a high temperature of melting, such that that rock reaches incandescence due to the frictional heating before it melts, then in that case a ribbon of red hot or white hot material, a streak, not an individual spark now, but a streak of incandescent material will form behind the progression of that pick.

One is sometimes asked what temperature of a surface is required to ignite a methane air mixture. In fact, the answer is not a single number. One must concern oneself with the energy level of the igniting source. For example, I need to explain that. If we have a small surface of a certain temperature that does not ignite a methane air mixture and we have in another test a larger surface of the same temperature, say, a dull red heat, then the methane may well be ignited by the larger surface even though it is at the same temperature as the smaller surface. So surface area as well as temperature matters. Two things: Temperature and surface area so far.

There's a third factor and that is time. The chemical process that we referred to as combustion, burning, ignition, is initiated with a temperature of the gas and the air mixture reaches ignition point of that mixture, and it takes a certain time for heat to transfer from the hot initial source to heat the gas/air mixture up to that ignition point. So a time factor is involved here.

So we need three things. We need that combination, and there's an infinite number of these combinations within limits. We need a combination of temperature, surface area of the hot surface and time of existence of that hot surface. This is why a continuous streak of incandescent material is far more capable of igniting a gas/air mixture than a shower of sparks because it has the high temperature. It has the surface area and it is continuous whilst the pick is moving through that particular hard and abrasive rock. So we have the time as well.

So continuing with these thoughts, the ignitions that occur in this way are normally associated with picks moving through either sandstone or iron pyrites. We have a number of references in the documentation to bands of pyrite within the Foord seam, and some of these references, Mr. Merrick, are repeated in my report.

How may we minimize the chances of such ignitions?

One way is to utilize water sprayers. Water sprayers were fitted to the continuous miners at Westray. The water sprayers that were used were directed at the cutting head, the cutting drum, and these would certainly help to inhibit a methane ignition. However, unless the jets of water are directed immediately and directly onto the back surfaces of the picks, sometimes referred to as "pick face fleshing technique," then they are unlikely to inhibit the formation of this incandescent streak that I talked about.

Another method of reducing the probability of ignition of the continuous miner would be, of course, and we've discussed this before, the efficient rapid removal and dilution of the methane that's produced at the pick point. And we've talked about the dust extraction system which would assist in that dilution, had it been running. And the reports we have available to us, a report we have available to us indicates that it was not running, the dust extraction system was not running at the time of the explosion.

Let me turn to the question of the boom truck at the junction of headings.

Q. Just before you do, Doctor, let me ask you one more question about a continuous miner and the picks. I understand that the picks have carbide tips?

A. Tungsten carbide.
Q. Tungsten carbide, and they have to be replaced periodically?
A. Yes.
Q. To what effect might there be on the tendency to cause a red hot, a streak of hot metal or hot stone, I guess, if the picks were not being regularly replaced?
A. This would increase the probability of such a streak being generated. A dull pick, a blunt pick, causes a greater crushing of the area of coal immediately ahead of that advancing pick through the coal. It utilizes more energy. The machine actually takes significantly more energy, more electrical power. All of this produces more heat at the pick point, more frictional processes, and, therefore, enhances the probability of incandescent streaks.
Q. All right, thank you.
A. Turning now to the boom truck. This was a diesel machine. It was the type that was not permitted to be used in the vicinity of the coal headings. And I call internal combustion engines, they contained a number of potential sources of ignition.
As you elicited from me this morning, Mr. Merrick, it was in a location where had methane layering, indeed, as we had postulated been taking place up Southwest 2-B.

The boom truck was in a location where additional turbulence would be caused by the presence of the truck itself plus the 145 degree turn. So it was, the boom truck was in the location where an explosive or an ignitable concentration of methane may well have existed. So we must include the boom truck as one of the probable alternative sources of ignition.

Turning to the third machine which was running, this was in the left heading of Southwest 2-1, this is the roof bolter. Again, the bolter power was found to have been on at the time of the explosion. Nevertheless, I would put this at the bottom of my three probable causes of ignition because the condition of the roof bolter was that both booms were in the down position, not up at the roof. It seems that roof bolting, the actual process of roof bolting was not on-going at the time of the explosion. Again, this cannot be said with certainty, but the indiction from the position of the machine suggests that it was not actually being used for drilling or bolting purposes. Power was to the machine. Power was available and switched on, but the machine appears not to actually have been used.

So my opinion on this particular matter is that we have these three probable sources of ignition. I would not want to choose between the continuous miner and the boom truck. I think that both of them, Mr. Commissioner, were equally likely to have been the source of this particular ignition.

I'm going to move on now, Mr. Merrick, to what happened immediately after the ignition. Do you have any further questions at this time?

Q. Just -- I take it that there are always other possibilities as well when one is never able to with absolute certainty find the exact source of ignition. Other possibilities are always possible. I've heard evidence that falling rocks can sometimes cause ignition and sometimes damage to cables. And we've heard evidence about several of these pieces of equipment, trailing cables and occasionally bumping into them, and we have records of cable damage in the mine. But I take it that in your opinion, these other kinds of causes, including smoking, torch work, et cetera, there is not sufficient evidence supporting those that you would put them on your short list in this area.

A. That is indeed the case. We have written down a fairly extensive list of possibilities and that, indeed, is quite a list. But in order to achieve some semblance of order into our investigations, we have one by one eliminated those. Not eliminated them as possibilities but eliminated them as probabilities, and we're left with the three sources that I've talked about.

Q. All right, thank you.

A. But you are, indeed, correct. They are possibilities, and we shall never know, to repeat myself, exactly which of those was the cause.

Q. I assume though that if the evidence does, with some considerable preponderance, indicate that the source of the ignition did occur in the general area that we're talking about, it is not perhaps quite as important to identify with exactness the exact source of the ignition as it is to identify that because of the way the mine was being run and the way the mine was being regulated that there were, in fact, several possibilities.

A. Yes, indeed. Frictional ignition of methane, unfortunately, is not an uncommon experience in coal mines, in mechanized coal mines. Most causes of ignitions and explosions have reduced over the years because of improved ventilation, because of improved safety procedures. The number of frictional ignitions has increased, particularly since the 1960s, and this is because of the increasing amount of coal-winning, rock-winning mechanization that we use. We're using more and more power, more and more machines to do this, greater and grater opportunities for frictional ignitions to occur. And, indeed, frictional ignitions of methane are not uncommon on coal faces, on longwalls, or in room-and-pillar workings. Fortunately, the vast majority of those ignitions get no further than a flickering of blue flame, backwards and forwards, and goes out. It's only in those rare cases where the ventilation has been inadequate to remove the larger bodies, larger accumulations of methane, it's only in those cases that the ignition, the initial ignition, develops into an explosion. Unfortunately, that is what occurred at Westray.

Q. Or perhaps I can take us back to one of the concluding comments of Mr. Golbey in his evidence where he said that the significance to be given to lack of planning was that it might allow a combination of factors to come into place that would permit a disaster to occur that would not have occurred if that combination of factors were prevented or cut off.

A. Yes, sir.

Q. All right, thank you.

A. So let us move on from the second in which that initial ignition of methane occurred. This ignition would be propagated only whilst there was a continuous path of ignitable, that is, in the flammable range, five to 15 percent, zone of methane. The burning, the blue burning flames of methane would propagate along the interfaces between the general air body and any higher concentrations of methane. We have referred, Mr. Commissioner, to the band of explosive flammable region between the high concentration at the top of he methane layer and the general body. It is along that interface that the blue flames would flicker and burn. And when a methane ignition occurs in that way, and there is no continuous path to larger accumulations, that blue flame may flicker backwards and forwards, fairly slowly. Indeed, in the 19th century, miners in the United Kingdom would sometimes intentionally ignite layers of methane above their heads purely for amusement, seemingly oblivious of the danger they were in. And they have that on record.

This is the kind of thing that I believe happened at Westray, not that that was intentionally ignited, but once the ignition had taken place, that these blue flames would flicker and burn along the interface between the general body and the methane layering above their heads. So this is not a mechanism where we suddenly have a large explosion. It is preceded by burning flames of methane moving backwards and forwards along the methane layer air interface.

Q. I take it that would explain or be one possible explanation why the bodies in the Southwest district were found in areas where apparently they had had some time to try to react, 10 seconds and more in some cases. And we saw Mr. Smales' demonstration of how long it takes to get a self-rescuer off the belt and on in the quiet of an inquiry room. But I take it that that would be one possible explanation for where the bodies were found and the time they had.

A. Yes, sir, they certainly had a number of seconds at least to unhook the self-rescuers from -- and unseal those self-rescuers. They had time to do that, and I believe that during that time, they were exposed to or had visibility of the blue burning flames of methane. They may have been right above their heads. They may have been at other locations that were visible to them along the heading. But, in either case, the methane was burning along the interface during this period, is my belief.

So now we have a situation where the flammable gas methane is burning along the layer air interface. Had that methane layer, had that accumulation, that local accumulation of methane not been connected to other accumulations of methane, then it would have performed in the same way that I referred to other common ignitions. It would have flickered and died out. The fact that this did not happen is an indication that the burning methane was connected to other accumulations of methane, connected to it in the sense that there was a continuous, call it a "fuse path of gas" from the source of ignition to those larger accumulations. And a methane layer, a continuous methane layer, would certainly have provided that continuous fuse path.

Q. So that that would be consistent with -- we know that the auxiliary ventilation, and I'm now looking at Exhibit 72, which is the large map on the board, which shows the locations of bodies and locations of the equipment in the mine at the moment of the explosion. That would be consistent with methane, if in fact it was the continuous miner where the ignition point occurred. That would be consistent with methane that might have layered in that heading from the cutting processes itself?

A. Yes, sir.

Q. It would have flickered back and forth and then connected possibly with a layer of methane coming up from the Southwest district.

A. That is a possibility, yes, sir.

Q. And if that was the case, if there was this layer of methane, you would then have a significant amount of methane, conceivably.

A. Yes. Let us look at two scenarios following along from your description. And that is that the ignition having commenced in this vicinity, propagating as near roof flames, and, incidentally, those flames, the thermal energy, the heating that is produced by those flames, would itself induce thermal turbulence. We talked about turbulence induced by air flow this morning. Turbulence can be and is also caused by temperature differences. This is why hot air rises up a chimney. It induces movement of the air.

So the very fact that we've got a hot source of burning gas existing at the roof or near the roof of this entry would induce further turbulence, would tend to accentuate the mixing, tend to make that methane be diluted down into the flammable range.

So what miners have been subjected to, and I have personally experienced this, is rolling flames over one head that do, indeed, become rolling. They tend to do this [witness rotates arm] and this gives the possibility that those rolling flames could, indeed, have come down onto the heads and shoulders of the miners. One often finds, Mr. Merrick, that hard hats, plastic hard hats have been melted, and it is often caused by this effect of rolling flames at head level.

However, continuing with this scenario you commenced, the ignition having started in this location, as we believe, propagated via concentrations of methane coming down the Southwest to B road and increasing in intensity as it came down because we have those cavities in the roof because of those falls that have occurred. Even if those had been supported, as I believe they were, there would still be voidage up in the roof with concentrations of -- high concentrations of methane, as we saw in the example of Mr. Raine's paper earlier. So this gives not only a propagating fuse path, but also connecting with larger accumulations of gas, continuing the propagation of the flame.

Now, at some stage, let us assume. Let us assume. Let me back off a little. Let us assume that that blue flame propagated through the methane layer interface all the way back to the stoppings at the old Southwest 1 entrance. It is possible that the burning methane connected to the tremendous accumulation of methane within the old Southwest 1 district. Now that is high concentration methane in a very large volume. Between that large accumulation of methane in here and the normal, what we've referred to as the ventilation infrastructure, here we have relatively low concentrations under normal circumstances. Here we have very high concentrations. And, as the Commissioner pointed out yesterday, that means inevitably that between those two, we go through a zone of the flammable region, five to 15 percent. So in the scenario I'm describing at the moment, if the flame had propagated down the Southwest 2-B and back into the old Southwest 1 workings, at that point it would have sufficient volumes of methane in the explosible range to develop into a very rapid, rapid flame propagation, a gas explosion. That is one possibility.

COMMISSIONER Doctor, when you say "propagate," I'm just trying to get a little thing on the time. When you say, okay, the blue flame started up here by the continuous miner and propagated down here, what are we talking about in time? Are we talking seconds or minutes or what?

A. Again, I'm unable to give a definitive answer to that because the speed of propagation of the flame depends upon the actual concentration. It will only propagate in the five to 15 percent range. The maximum explosibility is 9.5, 9.6 percent, but it does depend where in that range you are and the speed of propagation. And what we have, of course, in a methane layer is a progression right through that range from low concentrations to high concentrations. One has seen, and again, I personally observed this, burning methane propagating in one direction along a methane layer and then a few seconds later, maybe 10, 20, 30 seconds later, coming back the other way. So this can be quite slow.

COMMISSIONER That would be as the turbulence diluted the heavier --

A. Uh-huh.

COMMISSIONER Yeah, okay.

A. And oxygen gets back up there again. So this can be a process that can be quite long lived. And, indeed, in some instances where burning methane has been taking place in the waste areas behind longwall faces, one has experienced this also, those burning flames, sometimes called "hanging flames" can go on for hours. Again, we have records of that. So we have everything from the very high speed explosion itself through to things that can last for quite a long time.

Now going back to our scenarios here, the one I've described is the propagation of flames burning along the interface back into Southwest 1 and a major explosion, the major explosion -- not ignition -- being caused there.

There is another possibility, and that is that as the blue flame propagated along the methane layer interface connecting with these larger accumulations in roof cavities and causing the thermal turbulence, it is possible that even before that blue flame propagated back into Southwest 1, it is possible that a sufficient volume of explosive mixture was caused by this turbulence which would initiate the explosion, the very rapid flame, before getting to Southwest 1, somewhere in the Southwest 2-B Road.

Now I don't know which of these possibilities was, in fact, the case and, again, we shall probably never know. But somewhere, somewhere between the active headings and the Southwest 1 old district, somewhere along here, the burning, relatively quiescent burning of methane, developed into an explosion.

COMMISSIONER Doctor, would that be the point at which a shock wave, the explosion would kick up a shock wave which would then, in fact, stir up the coal dust?

A. That is exactly the situation, sir, yes. So let us take it from that point onwards.

Now we have a gas explosion. A gas explosion, like any other explosion, results in a very rapid increase in temperature of that volume of gases/air mixture that is involved in that initial explosion, a very rapid expansion, indeed. That will cause a shock wave to develop and to propagate in all directions away from that point of explosion.

Now if that explosion had occurred in here, then the shock wave could not propagate too much in this direction and, in fact, we do not believe it propagated in that direction much at all, but it has perfect freedom to come out into the main body of the mine. It doesn't have the resistance of the dead ends of headings to prevent it. So the shock wave would propagate outbye, increasing in intensity and would continue to propagate because of this mechanism.

Let us take our mine airway. We now have a situation where a shock wave has been set up. This shock wave is proceeding at high velocity away from the initial seat of the explosion. And remember this shock wave has been caused by the expansion, the thermal expansion of these gases. So this propagates away from and in advance to the actual burning gas itself. So behind this we have so-called "flame front."

MR. MERRICK This is going to Chart 4, for the record.

A. We've now got two significant zones here. We now have a flame front where the burning gas, rapidly burning gas, exploding gas, is propagating along the entry that is causing expansion and pushing the shock wave further and further in front of it. Now this shock wave is a region that separates the normal atmospheric barometric pressure of the mine entry in front of it between that and the expanding region where the pressure is obviously more elevated. It is that higher pressure that is pushing the shock wave forward. So we've got a peak here of pressure and any objects that are subjected to that shock wave will, over a very, very short time period, milliseconds, find themselves or find it, the obstacle, hit on one side by this high pressure shock wave with a lower pressure behind, and this is what causes blast damage in any kind of explosion. This is what causes the damage, the blast damage.

Okay, there's one more unfortunate thing that the shock wave will do. Because of this tremendous turbulence that's caused and this blast damage as I've described it, and that is that this will certainly be capable of raising dust from settled surfaces into the air, including the coal dust, or coal dust/stone dust mixture. And if that mixture is of a sufficiently high combustible content, then the particles of coal themselves will be ignited.

And the methane gas explosion then converts into the much more violent coal dust explosion. Much more violent because there is much more calorific value, energy content, in coal dust per unit volume than there is in methane gas.

The concentration of coal dust required to propagate a coal dust explosion is quite high. A coal dust explosion will not be propagated unless it is at least some 50 grams of coal dust per cubic meter. Now these numbers may not mean too much, but 50 grams per cubic meter in the atmosphere in this room would make the atmosphere opaque. You would not be able to see your hand in front of you. It would be that thick.

This degree of dust concentration is unlikely to occur in any mine by normal mining processes. It is only the violence, the energy level of an initiating gas explosion that is likely to cause a coal dust explosion. There have been coal dust explosions propagated very rarely in other ways, but the usual mechanism is the one I've described, initiated by a methane dust explosion.

So now we have the methane explosion developing into this much more violent coal dust explosion. Now where that conversion took place, again, we shall probably not know with certainly, but my impression is that a coal dust explosion commenced before the shock wave and the following flame front reached the mains. So somewhere in here, we converted from a methane explosion to a coal dust explosion. I base that opinion on the fact that the violence of the explosion by the time it reached the air crossing here and the stoppings, the devastation that was caused here is certainly indicative of the violence of a coal dust explosion.

COMMISSIONER Just one question apropos of that: Does the coal dust explosion gain in energy as it propagates?

A. A coal dust explosion never reaches equilibrium. It is either proliferating or it's dying. And it can rise and fall in intensity depending upon the availability of two things; first of all, the coal dust which provides the fuel; and, secondly, the oxygen that it requires to propagate the flames. So it is a very highly dynamic phenomenon.

Now what we feel occurred when the dust explosion actually met the mains causing the tremendous amount of damage that we can see on the photographs of the stoppings, of the air crossing, I believe that the shock wave and following flame front propagated both north and south, both ways along the mains, particularly in the No. 2 entries. Because this is where the conveyors were. This is where exceptionally high amounts of coal dust fuel were available, along the conveyor roads.

So the belief is, my belief is, that the explosion propagated. Let's take them one by one. Let's take, first of all, the propagation of the explosion, the coal dust explosion up the No. 2 slope all the way through to surface. As it progressed up No. 2 slope, then these shock waves would beat upon the stoppings in the crosscuts. The explosion may have propagated into the intake. There was less fuel there. We saw the analyses. Less fuel there to propagate the coal dust explosion, but it certainly propagated all the way through to surface and out through the portal of the No. 2 entry.

MR. MERRICK That would be consistent with all of the crosscuts between the intake and the return mains being blown out in the direction of the intake main?

A. Yes, sir, exactly.

COMMISSIONER Would the shock wave not lose some energy as it turned a right angle to go into the crosscut?

A. This is an interesting question and one that I'm going to come to and talk about more when we look at the North. What happens is that when shock waves, when explosive waves meet obstructions or anything to deflect them, turns, corners, junctions or pieces of equipment, that, in some areas we get the shock wave being accentuated, made stronger, and very close by, we may have a shadow area where the shock wave has hardly hit at all. And it is a common feature in post-explosion investigations, Mr. Commissioner, that we'll see extreme devastation, wrecking of sturdy roof supports and just a few feet away, we'll see fairly light equipment that's hardly been touched, and it's because of these deflections and reflections. It's a very complex, and let me repeat the word, highly dynamic phenomenon.

So that is following the explosion wave up the slope or slopes, let us follow the path now northwards. As we've said, recapping, my belief is that the explosion came out of the Southwest and turned in both directions. Turning to the North, the explosion shock wave and following flame front would progress northwards. It probably progressed northwards in all three of these entries.

Now we're faced with a somewhat different scene here. Coming out of the portals, the shock wave and the following flames had the freedom to escape to the outside atmosphere. Here we're faced with dead ends everywhere. There is no escape to surface. The mechanism that we postulate now, and we're hypothesizing at this stage, because no one has ever observed this and lived to tell the tale, but because of the obstruction to this shock wave, we believe that that shock wave would propagate into the headings, cause severe blast damage, nowhere for it to be relieved within those headings, be followed by the flame front which also had nowhere else to go. That flame front would terminate, it is my belief, would terminate in a short period of fairly intense burning of methane and coal dust in these headings, and would be terminated either by lack of fuel, lack of further coal dust and gas, or more probably, lack of oxygen. But there would be heavy blast damage followed by heavy burning. Which explains also some of the photographs that we can observe.

COMMISSIONER   Doctor, why wouldn't the same principles that applied up in here in the Southwest district, the principles that you say the shock wave couldn't propagate up there because of the dead ends, why wouldn't that same principle apply up here?
A.   Let me use an analogy, Mr. Commissioner. When you fire off a rifle or a shotgun, you are hopefully at the safe end of it behind the place where the bullet is going to be ejected. The energy, the kinetic energy, of that bullet increases as it goes along the barrel and is ejected and is fairly quiescent, hopefully, at the end where you're pulling the trigger. This is the trigger end of this explosion. It is initiated, as we've explained, by burning methane. The propagation would be outbye and would increase in intensity coming outbye and this is, again, a very commonly observed phenomenon in investigations of -- the post-investigation of explosions. That actually at the seat of the explosion, where it started, where it ignited, that is the place where you find least blast damage.
COMMISSIONER   I see.
A.   Because of this effect.
COMMISSIONER   Kind of like the eye of a storm?
A.   Yes, indeed.
COMMISSIONER   Okay. Thank you.

MR. MERRICK I suppose, maybe this is too graphic, but if that's where the ignition occurred in the Southwest District, it was a blast aimed right down into the North Mains?
A. Yes, sir.
Q. That would be consistent with the evidence that we have that the miners in the North Mains had no warning whatsoever?
A. That is correct.
Q. And would account for what we understand to be the evidence of considerable and extensive damage not only to equipment but to the headings themselves?
A. Blast damage and burning, yes.
Q. All right. You were describing what happens when it gets into the blind, the dead ends.
A. Well, I think I should have little to add, Mr. Merrick. I think what we have just gone through is a scenario like any other post-explosion investigation, is one that cannot definitely be proved. Everything I've said is backed up by the evidence that we have looked at and is consistent with the facts that we have found.
Q. We have heard -- we have seen some indications and seen some opinions to the effect that once the shock wave and the -- got down into the North Mains that it may have reflected there or come back out again?

A. Yes.
Q. What do you say as to that?
A. It is possible that this could have happened. Again, it's -- the situation in many cases, and we can look at, at least one example of this in Westray, where a piece of equipment has been blown, propagated in one direction, and another piece of equipment which was originally very close by has been propagated in the opposite direction.
Q. What are you referring to?
A. Why does this occur? The belt end, the box, belt box, which I think was in approximately this direction, seems to have -- and the air crossing. The air crossing at this position. The evidence seems to suggest that some of the debris moved in one direction; some in the opposite direction.
Now this can be explained through the Commissioner's question about reflections and deflections. We do indeed get the situation and can observe the situation where shock waves can move in one direction and followed a little later by shock waves moving in another direction. A different intensity. Another phenomenon that occurs is that this rapid expansion -- this rapid expansion caused by the burning and the heating, let's take the Northwest as the example, will be followed quite quickly

afterwards, after the depression of those flames, by cooling. Cooling of the system which will pull air back in. And we sometimes get a reverse implosion that can move things back in the opposite direction. So there are a number of explanations for this.

Q. We may hear evidence later on that would suggest that right up in the Southwest 2-1 Road, I think, if I've got my designations correctly. Anyway, where the continuous miner was, that they may have encountered a fault right at the time. To what extent might that be consistent with and also explain additional gas make at that time.

A. This is a matter we looked at briefly yesterday. Within the vicinity of a fault or most other geological anomalies, the strata, including the coal, would have been disturbed over geological time because of the movement of that fault or anomaly, and therefore, would have been subjected to greater stress, inducing strains, that is, fractures, micro and macro fractures, and therefore would become more permeable. The gas would have been emitted more freely into the workings in the vicinity of faults.

Q. We should never, I suppose, lose sight of the human aspect of this and the human tragedy part of it. The mechanism that you have described would have had that

blue flame and perhaps rolling flames coming down to head level up in that Southwest district for a matter of some seconds at least, that must have been a very terrifying time.
A. Indeed, yes.
Q. Let me ask you a very general question. In this day, in this age, should that ignition have occurred?
A. Had there been adequate ventilation in the headings of the Westray Mine, any ignition of methane that might have occurred through cutting picks on machines or any other purpose would have remained localized, as indeed most of the such ignitions do remain localized; it would not have developed into an explosion.
Q. Let me put it in stronger terms and using the extension of the question that you've used. Accepting for the moment that you may get ignitions in a mine, is there any excuse to allow an ignition that may occur in the Southwest district to blow that whole mine up?
A. My answer must remain the same, Mr. Merrick. Had the ventilation of the headings been good and adequate, it would not have propagated into a gas explosion. And let me add to it, had the mine dust been sufficiently diluted and regularly diluted by stone dust to within the legal limits, then it is much less likely that that gas explosion would have developed into the much more violent

coal dust explosion.
Q. Doctor, my impression is, and I'm just a lay person on this, that coal mines are a very dangerous place. And mine explosions have been common throughout the history of coal mining, but I would assume that in North America at least and also other parts of the country, with the knowledge that we have gained from previous disasters, we may have to expect accidents to still happen at faces and in headings, but surely we should no longer to blow up whole mines?
A. The number of explosions that occur in the end, towards the end of the 20th century is, of course, minuscule compared with the 19th century and the 18th century. So the number explosions and the horrendous loss of life in the first 100 years of industrial revolution, those days are long gone behind us. So in answer to your question, the number of explosions in coal mines has decreased orders of magnitude and that is as it should be because we have better procedures, better ventilation, greater amount of knowledge on safety and the health of the miners.
So as a direct answer to your questions, we should not expect that explosions should occur in mines. Nevertheless, to be absolutely realistic about it, and as Westray has shown, such incidents do, unfortunately, but

very rarely, occur.

COMMISSIONER I just want to follow up on a question Mr. Merrick posed to you a few moments ago about the miners who were in this area at the time and the tremendous traumatic experience that would have been for them at that particular moment.

On another way, if we get up into this area, Doctor, you were saying that how the energy of the shock wave propagates and increases over the course of the time. Is it fair to assume that the miners who were up in this area really didn't know what hit them?

A. That indeed could be the case. That the strength of the shock wave hitting into that blind end, hopefully, would have been quick.

COMMISSIONER Yeah. That's what I was wondering about. Yeah.

MR. MERRICK Let me come back to my line of questioning that we were just exploring. One of our mandates is to answer the question: Was this disaster preventable? I can't help but assume, based on even the evidence that we've heard to date, is that the answer to that question is a resounding, resounding, "Yes, it was preventable." Do you agree with that?

A. Absolutely.

Q. And what we have to do, based on your evidence and the evidence of others, is to identify how it was preventable.

Let me take you -- just to summarize your report. Tell me the things that contributed to it and the things that could have been done that would have prevented that moment in that mine.

A. Well, these are summarized on -- starting on page 41 of my report. So let us look at these together. The fact is that I've listed what contributed towards the probability of a gas explosion resulting in a succeeding coal dust explosion. First of all -- and this is recapping these last two days.

First of all, a system of auxiliary ventilation that was clearly inadequate to dilute the methane rapidly, efficiently. Was clearly inefficient -- insufficient to prevent the formation of methane layers.

The air flows and therefore the air velocities were too low in the active headings. Exhausting systems of auxiliary ventilation were being used which would mitigate against good mixing and adequate mixing at the working faces.

We've talked about ventilation ducting that was too small for the air flows that were required in the headings, indeed, it was too small for the air flows that they did achieve, resulting in the inward collapse of the tubing, you recall. We've talked about headings being ventilated in series.

And we have not talked, Mr. Merrick, in your examination of me with -- about the cable damage. Nevertheless, there were frequent incidents of cable damage. Concentrations of gas --

Q. Just before you go on --

A. Yes, sir.

Q. -- and just for the moment on the cables. While that may or may not have been a direct -- while that may not have been a direct factor in the ignition of this particular explosion, that is something, nevertheless, I take it that we should continue to look at and examine. Because ultimately it could have been an ignition point in an explosion and it certainly would relate to the safety of the operation of the mine. I'm right on that, am I?

A. Yes, indeed you are. In the table that summarizes my observations on the foreman's reports, there are a number of incidents of cable damage. We do not have any evidence that cable damage was the cause of this particular ignition, but reflecting your statement that this is an indication of perhaps less than adequate training of the miners in handling those cables. And, indeed, if that had continued, this would have been, and indeed it was, a possible source of ignition.

We've spoken about the high gas concentrations in the headings, sufficiently high that mining was interrupted from time to time.

Another point I make in this paragraph is that when dangerous occurrences do occur frequently, then the sense of danger, the sense of hazard, decreases in the minds of the personnel. We often hear references to the inuring of peoples' minds against violence these days because we see so much of it in television; the same psychological factors come to bear here. When miners are exposed daily and weekly to dangerous situations and they do not get blown up, Mr. Merrick, then a sense of false security develops in their minds that this is okay. It wasn't okay, as we've seen.

COMMISSIONER And would that point be exacerbated by the fact of inadequate training so that the miner didn't know, you know, what to fear?

A. Yes, indeed, sir. That would contribute towards it.

COMMISSIONER Yeah. Okay.

A. We've spoken about the possible misuse of emergency or cutoff switches. We've talked about conditions of ground stressing, ground roof falls, sloughing, the crushing of the coal in the old workings that would encourage the production and the emission rate of methane. We've spoken to the high concentrations of combustible material and the dust. We've spoken about intake air serving the Southwest 2 district after having passed across the entrances of inadequately sealed old workings.

We've spoken about the possibility of layering extending from those old workings up into the vicinity of the headings.

We've spoken about the use of non-permissible diesel equipment in the vicinity of those headings.

And we've spoken about the falling barometric pressure.

All of these could well have contributed to the initiation and the propagation of this explosion. Those are the technical factors that I have listed in my report.

MR. MERRICK You go on to list about five or six more that you say, while not technically, or a technical factor are, nevertheless, factors.

A. These comments at the bottom of page 42, right at the end of my report, are the comments of a mining engineer, Mr. Merrick. Everything up to this point has been -- have been the comments of a mine ventilation engineer. I add these few other matters at the end speaking as a general practitioner now in the mining industry and having spent a lifetime working with and in the mining industry. These are matters which are non-technical in the sense that they reflect on the actual operation of equipment or behaviour of the ventilation system. But, nevertheless, in my mind contributed in an equally potent manner towards the propagation of a mine explosion. And you can look at these for yourself as I run through them.

Inadequate training of mine workers. Eight-hour shifts not being used, but 12-hour shifts being employed. 12 hours in the arduous conditions of any underground mine as a routine and continuous procedure is much too long. Normal period, of course, is eight hours. Many mines use seven hours. Some mines in the world have now gone to four shifts working six hours, Mr. Commissioner. 12 hours is excessive. Not only from the point of view of the human aspects of working 12 hours at a time, but also because of the inevitable loss of attention that can result and has resulted all too often in accidents and deaths occurring in mine. You are very reliant for your safety, not only on yourself, but also on the guy next to you. And if you've been working for 12 hours, that attention is going to slip.

A concentration of attention on the problems of roof control at the expense of other safety issues. You have already heard of the severe problems of roof control/ground control, the falls of roof, and this was a major, major concern to the mine management. This was a major concern to the mine management, I would hope, from the point of view of the safety of the miners. There is another factor, however.

Falls of roof inhibit the mining process itself. If you have falls of roof, then you cannot get your coal out; you cannot get your men and materials and equipment in. A fall of roof in part of that infrastructure of the mine will cause a cessation of mine because, physically, you cannot get the equipment, the people in. So not only is this a matter of safety, it also results in cessation of production in that part of the mine.

Problems associated with poor ventilation do not necessarily do that. If you have poor ventilation, then you can keep mining, as, indeed, happened at Westray. So although it is equally a matter of safety and health, as the falls of roof are, it does not immediately prevent production. It will inevitably do so in the long term, sometimes with tragic consequences, as we've seen at Westray.

A drive for coal production so intense that it conflicted against a prudent regard for safety. This, I think, ties up with what I said a moment ago, that there was, indeed, an immense drive on the men, on the management, to produce coal. Those pressures would seem to have been, indeed, heavy to the extent that it did, indeed, conflict against a prudent regard for safety. An example arose this morning, Mr. Merrick, when we were talking about preventing methane coming out of the old workings. Could have put better seals on, proper seals, double wall seals. Could have had a back bleeder system to keep the gas back from those intakes. Could have had pressure balances. Could have had an air crossing. Could have done all of those things. Why were they not done? This was not going to produce coal. This was going to take time. This was going to take money. And drive for coal production so intense that it conflicted against a prudent regard for safety.

Q. Just as backdrop to that comment you just made, I would suggest that that comment is particularly appropriate knowing as we now know at least some of the circumstances on what happened at the end of March. They were coming off a period when they were driving to increase their coal production to hit their targets that they had. They had had several good months of production and then got chased out of that old district and had to find another place to develop coal in a matter of days.

A. Yes.

Q. Thank you.
A. Moving on. A lack of detail in the initial planning of the mine. That should have been a prerequisite for financing and authorizing the project. Let me confine myself just to the ventilation aspects of this. I have seen no ventilation plans that I would honour with the name of "ventilation plans" for the development and the long term planning of this mine. I have seen plans showing production layouts, plans that seem to have changed quite frequently. I've seen no commensurate ventilation plans to go along with those layouts.
My final point, a lack of rigour by government and its officials in insuring that the mine was operated in a safe manner, particularly with regard to concentrations of methane and coal dust. I'd like to preface those remarks and final remarks on this matter by saying that mine inspectors around the world have a difficult job. They have a duty of administering, enforcing, often interpreting the law, and they have the job of doing all of that with some sensitivity and, at the same time, making the lives of the mine operators, the mine management such that they can continue their profession of mining coal or mineral. Nevertheless, the predominant feature over all of this must be for the inspectorate to be concerned with the health and safety of the miners.

There are some matters which I certainly have questions in my mind. The matter of coal dust and the lack of stone dusting during the physical inspections of the mine by the inspectorate -- this must have been visually obvious to them. And, indeed, the warnings and eventually the orders that they gave on April 29th indicated that they were, indeed, concerned with rock dusting. I would have thought it would have been prudent for them to take stronger action earlier on the matter of combustible dust in the coal dust/stone dust mixture.

It would have been prudent also for the mine inspectors to have looked at the reports that were being produced, that were produced under the law by officials of the mine and, in particular, I have in mind the ventilation so-called "survey reports."

Even a fairly cursory glance through those reports would have shown matters that should have stood out like red flags to mine enforcement officials. I refer to the high concentrations of methane that were reported.

I refer to the recirculation, the uncontrolled recirculation that was occurring in the North workings. These are matters that should have resulted in fairly rigorous action to rectify these matters.

I would suggest that the mine should have been subjected to sanctions because of these infringements against the law and going beyond that, because of the disregard for safety that seems to have been the philosophy at Westray. And those actions may well have started with warnings, formal warnings, followed up by more stringent sanctions, citations, and followed up, if necessary, if no action is taken, by a stop work order. And, indeed, in cases of perceived immediate danger, there again, stop order, stop work orders may well have been issued.

Let me finish with that, Mr. Merrick.

MR. MERRICK Thank you, Dr. McPherson. Mr. Commissioner, I do have two other areas that I want to touch on with Dr. McPherson, which I'll do in the morning, I think would be appropriate.

COMMISSIONER Okay, fine. Thank you. We'll adjourn then until --

MR. MERRICK Just before we break, if I can make one explanatory comment to counsel. They will have noticed in Dr. McPherson's report that he refers to transcript evidence on occasion and purports to have it in quotations. We've attached in the exhibit books the actual pages from the transcripts from which those quotes were taken. The words do not exactly match; the substance does. The reason for that is that Dr. McPherson was given summaries of the transcripts that paraphrased the exact quotes so that they aren't exact quotes but they are essentially the same message. That's it.

COMMISSIONER Thank you.

HEARING ADJOURNED (TIME: 4:40 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 21st day of November, 1995, at Stellarton, Nova Scotia.