MR CILLIERS: You went on to speaking about the possible cause of the fire. I think we skipped some material in between which doesn't matter, whichever way you want to put it.

MR SOUTHEARD: But basically my conclusion was, having eliminated human agency as in terms of cigarette ends or carelessly discarded cigarette ends, I believe the fire started as a result of something in Pallet PR, within the cargo.

MR CILLIERS: Alright. Now if one takes your reasoning so far and one looks for support for it Mr Southeard, you postulated that you've got a fire starting in the right-hand front pallet, now what do you say about the geometry of the fire from what you can see from DR FOWLER's measurements and from your own observations? If the fire started in the right-hand front pallet, where did it move to from there and how did it spread?

MR SOUTHEARD: Bearing in mind that DR FOWLER estimated or gave me temperatures of 288° to 300°, the area that I was interested in is the area between stringer 15R and 14R, between the body stations 1800 to 1820. If we could look at that plan?

MR CILLIERS: Have you got those diagrams with you?

MR SOUTHEARD: No. You've got them.

MR CILLIERS: May I, for the convenience of the members of the Board, hand up a copy of the plan to which the witness will refer?

/This will ...

CHAIRMAN: This will be EXHIBIT "U", Mr Cilliers.

MR CILLIERS: You'll see it consists of two diagrams, Mr Chairman. The one looking at the top down upon the pallets and the other is looking standing, as it were, on the floor of the aircraft.

CHAIRMAN: The one is a plan and the other is a section?

MR CILLIERS: Yes. A plan and a section.

MR SOUTHEARD: If you look at Section "AA" which is the second one, you'll see a cross-section of the fuselage including the pallet, and the position between stringer 15 and stringer 14.

Now if we had an ordinary cardboard box fire which just involved the materials contained within the packaging and the cardboard boxes, there are only certain levels of energy which that can reach and that is restricted by the amount of air that you can get into the flame as it burns. And the things that regulate the intensity of that flame are things like what we call emissivity. Now emissivity is the opposite to absorbivity which, if you've got a shiny aluminium surface for example, and you radiate that with heat, that will reflect a lot of heat and therefore it won't see much of the heat itself. Whereas if you've got a very black matt body, that will absorb a lot of heat.

/Now ...

Now this is the analogy to that, but in reverse. Whereas if you have a black thick object radiating heat, you'll radiate a lot of heat. Whereas if there's a thin shiny body, you're not going to radiate much heat.

Now what I did, I took DR FOWLER's figures of 288° to 300°, and bearing in mind we're looking at the bay between stringer 15 and 14, between body stations 1800 and 1820, and I calculated the maximum amount of energy that you could get from a normal diffusion flame fire, which I got to be 148 kW/m².

Now I had to rely on BOEING for figures regarding the airflow and what we call the "Reynolds number" which is a measure of the turbulence passed the aircraft, and using their figures for that I can calculate the energy or the heat transfer from the skin to the outside air. And in calculating the heat transfer, I could then calculate the energy required to heat that section to 288° or 300°, so therefore I could calculate the amount of energy required to reach that temperature on that skin, and the amount of energy required is 100 kW/m². So you can see that that is within, in itself, the range of a diffusion flame fire. That is an

ordinary cardboard box fire. But given the configuration, and this is the important part to me, the configuration of that position versus the pallet, in other words it's got to go at virtually 45°, I would have to envisage a very channelled localised fire to reach that temperature in that localised position, bearing in mind that the bays on either side of 1800, forward of 1800 and aft of 1820 were not heated to any significant extent. And therefore I believe that this is evidence of a promoted fire. In other words a fire which has its own oxygen source and has originated from either an incendiary device or some chemicals contained within the cargo, and it is not consistent with an ordinary cardboard box fire because of its localisation, its direction and the energy required.

MR CILLIERS: If an ordinary diffusion fire had to produce that amount of energy, how wide across the pallet would it have to stretch, keeping in mind the narrow band where we get the high temperatures on the skin?

MR SOUTHEARD: If you're looking at the fire starting there as a normal diffusion flame fire, you wouldn't get the thickness. In order to get the amount of energy, in other words the emissivity in this flame, you need to have a flame length of about - or a flame thickness - of about nearly 1m. So you're extending that almost halfway across the

pallet, and yet you're restricting that flame between 1800 and 1820.

MR CILLIERS: So a combination of the temperatures established by DR FOWLER's conductivity tests supported by the tests, and the geometry would then lead to the conclusion that it is not - that amount of energy could not have been generated by an ordinary diffusion fire, but it needed to be a promoted fire?

MR SOUTHEARD: That is correct.

MR CILLIERS: Well that is one ground that you have for concluding that it was a promoted fire.
What do you say about the evidence which one can gather from the time that elapsed between the alarm bell and the cockpit voice recorder going out of action and assuming, I think as most witnesses have accepted, this is due to the wires in the crown leading the CVR being burned through?

MR SOUTHEARD: Yes. All I can conclude from that is that I believe that by the time the fire was detected, you had a significant build-up of fire across the crown. You've got a delay of - depending on whether you take it to the signal - the test signal - or to the cut-off, we've got 1 minute or 1 minute 21 seconds, I think.

MR CILLIERS: Yes.

/But it's ...

MR SOUTHEARD: But it's a very short time between detection and going through those wires. And bearing in mind the time that it would take to go through those wires, I believe that you've got a rapidly developing fire by the time that the fire has been detected in this case.

MR CILLIERS: That fire that develops so rapidly in the time, that is assuming that the detection is at an early stage of the fire - the force of the fumes there - and that from the detection moment to the time when the wires leading to the CVR are burned through is only 1:20, is the development of a fire of that magnitude in that time, is it indicative of a promoted fire, or is that consistent also just with an ordinary cardboard box fire?

MR SOUTHEARD: If you're assuming that it was detected early then it's obviously consistent with some sort of accelerated or promoted fire.

MR CILLIERS: Yes. And the material which is likely to ignite, Mr Southeard; when one has looked on the one hand between materials involved in a promoted fire, that is which provides their own fuel, and materials which don't provide their own fuel, where does the probability lie between these two categories for ignition without human intervention?

MR SOUTHEARD: We could postulate I suppose, that you had two cargoes that we didn't know about. One was the igniter and

/one ...

one was the promoter, but it seems more likely to me, and as there are so many examples which could have an ignition source within a promoter, for example peroxides, any oxidising agent, finely divided metals, catalysts, there are a lot of substances - chemicals - which when for example if spilled or damaged, could cause a fire and then promote it rapidly.

MR CILLIERS: Yes. Now you've had a look at the manifests here. In this case was there anything which indicated that there were materials in there which would lead to a promoted fire and be more likely to self-ignite?

MR SOUTHEARD: No, I couldn't see anything in that cargo list which would lead to this sort of promoted fire.

MR CILLIERS: MR VAN ZYL earlier on expressed the view - it was only a view - he said that it seems as if there was something undeclared in the cargo which led to this. Not specifically enough to declare that one can see it now. Do you agree with that?

MR SOUTHEARD: Yes, I would agree with it.

MR CILLIERS: And so in the result for the reasons that you've given it would be right to say that in your view, for three really different but supporting reasons, that you're of the view that what we had in this cargo at the back there on the main cargo deck compartment was a promoted fire?

MR SOUTHEARD: That is correct.

MR CILLIERS: Thank you, Mr Chairman.

CHAIRMAN: Mr Southwood?

MR SOUTHWOOD: Thank you, Mr Chairman.

MR SOUTHEARD cross-examined by MR SOUTHWOOD:

MR SOUTHWOOD: Mr Southeard, your view that this was a promoted fire rests on an assumption that there was early detection?

MR SOUTHEARD: No. No - not in - no, it doesn't. I mean that was just one aspect. All I'm saying there as a result of the detection is that it was rapidly developing by the time that it was detected.

MR SOUTHWOOD: Yes, but you also associated that with a promoted fire?

MR SOUTHEARD: That was one of the - yes, alright that was one of the aspects, but that isn't anything to do with the heat generated at this particular spot.

MR SOUTHWOOD: If there was not early detection, if the fire had smouldered for some time before burning fiercely, how would that affect your view about a promoted fire?

MR SOUTHEARD: Well if you had a slow smouldering fire, by the time that it has been - if you're postulating there's something wrong with the detection system and it hasn't been detected - by the time that that does spread you've got a large fire, and in order to get these sorts of energies in the localised position, I believe you've got to have a very localised fire there. By the time you've got a normal cardboard box fire spreading, you're going

/to ...

to spread out in each direction involving the cardboard next to it, and therefore you've got a fairly large area fire.

MR SOUTHWOOD: When we consulted MR HILL of the FAA yesterday, he found that the high temperatures were consistent with cardboard boxes and wooden boxes.

MR SOUTHEARD: Yes?

MR SOUTHWOOD: And he also found that that was consistent with this "hot spot", that there could have been just cardboard boxes and wooden boxes burning. Do you recall that?

MR SOUTHEARD: I recall that, yes.

MR SOUTHWOOD: Do you have any comment on that, because you seem to be at odds with that?

MR SOUTHEARD: No, I don't. Yes, I don't know MR HILL's reasons.

MR SOUTHWOOD: No further questions.

MR PUCKRIN: May it please you, Mr Chairman.

MR SOUTHEARD cross-examined by MR PUCKRIN:

MR PUCKRIN: Mr Southeard, do you rule out the possibility that the phenomena which you witnessed were caused by an ordinary diffusion fire?

MR SOUTHEARD: If you ask me: Is it impossible that it was caused by a diffusion flame fire? I would have to say: No. Correct.

MR PUCKRIN: What maximum gas temperature have you assumed in order to make your calculations?

MR SOUTHEARD: Maximum gas temperature?

MR PUCKRIN: Yes, for a diffusion fire.

MR SOUTHEARD: 1000°. The flame temperature.

MR PUCKRIN: The flame temperature?

MR SOUTHEARD: Yes.

MR PUCKRIN: Now if the assumption is made that the maximum flame temperature of an ordinary diffusion fire involving packaging materials is 1100°C, would that materially affect your conclusion?

MR SOUTHEARD: No, it wouldn't because the difference between 1000° and 1100° is not that great, but I still believe 1000°C is the right temperature to take for a normal diffusion flame.

MR PUCKRIN: Well let's assume that it's 1100°. Would this fire then be more consistent with an ordinary diffusion fire?

MR SOUTHEARD: I believe not due - just on this geometry - that

you've got to get a thick flame in that area to get that amount of heat.

MR PUCKRIN: Yes. Now let's consider the geometry? There's one unknown in this whole equation and that is how the insulation blankets collapsed?

MR SOUTHEARD: That is correct.

MR PUCKRIN: We don't know at what rate and in what shape that collapse took place. Is that correct?

MR SOUTHEARD: That is correct.

MR PUCKRIN: Let us assume that the insulation blankets collapsed in that "Y" form and remained there for 5 or 10 minutes whilst an ordinary diffusion fire raged. That would certainly account for the geometry which is called "a hot spot".

MR SOUTHEARD: But I can't explain why, if the fire is that localised - if the fire is very localised then I could explain that. If the fire is a general diffusion flame fire, then it would be affecting the bays either side of 1800 to 1820 in the same way.

Now we know that the frame 1800 and 1820 have sustained heat and the blanket clips have gone, so what holds up the blankets either side if it's a general fire?

MR PUCKRIN: One doesn't know at what rate those clips are collapsing, does one?

/No, but ...

MR SOUTHEARD: No, but we know that it's gone in the middle so why doesn't - I can't envisage why the others wouldn't go in the same way if you've got a general fire. This is my point about it being localised. It's got to be localised to just take out one blanket in my opinion.

I mean there's nothing. In other areas of the aircraft there are cables, there are wire rungs, which may inhibit the falling of blankets, but in that area those three bays are identical. I can't rationalise why one blanket shall fall off and the other two stay intact, given a general heat in that area.

MR PUCKRIN: Yes, but what might well happen is that one blanket would not fall off catastrophically as a whole, but a corner of it may begin to peel and progressively detach?

MR SOUTHEARD: But the things that are holding those blankets on are the cap strips which go over the frames ...

MR PUCKRIN: Correct.

MR SOUTHEARD: ... and the blanket holders.

MR PUCKRIN: Yes.

MR SOUTHEARD: Now I don't see how you progressively take off a corner. Those are the things that are going to go first. They're going to go at 250°.

/They need ...

MR PUCKRIN: They need not all go at the same rate?

MR SOUTHEARD: No, but they are going to come away.

MR PUCKRIN: I'm only putting to you that isn't it reasonable to assume that the blanket would not have come down instantaneously, but that it might have come down in degrees?

MR SOUTHEARD: But I can't see - if you're heating up a portion of 1800 to 1820, it's the same blanket clip that holds that bay to the next bay. If you've destroyed that bay, why aren't you destroying the same area in the next bay?

MR PUCKRIN: Mr Southeard, I just want to clear up one aspect of your report on page 8, where you talk about a steady state fire which is the equivalent to a fire involving an armchair or a large settee.

MR SOUTHEARD: Yes.

MR PUCKRIN: As I understand it, this is only your description of the steady state fire, but it's certainly not a description of the maximum fire?

MR SOUTHEARD: That is correct.

MR PUCKRIN: The maximum fire could have been a great deal larger. Is that correct?

MR SOUTHEARD: That is correct. What I envisage happening is once the fire starts it then - flames would come across the crown of the aircraft and use up the oxygen which is within that cargo compartment at that time. From then on it would die back

and would rely solely on the ventilation which is coming into that compartment.

MR PUCKRIN: Mr Southeard, did you find any positive signs of a promoted fire?

MR SOUTHEARD: No, I didn't.

MR PUCKRIN: So it's all based on the assumptions which you've made?

MR SOUTHEARD: That is correct.

MR PUCKRIN: Yes. Can you tell us something about your opinion in regard to the smoke generated in the maindeck cargo hold, and whether it would have breached zone 1; Zone 1 being the area immediately for'ard of the bulkhead and galley 4B.

MR SOUTHEARD: I can't give you an opinion on the smoke. All I can say is that if there was a fire in that cargo compartment, then you would have got pressure in that cargo compartment. And as I understand it, the pressure differential which is supposed to be maintained, could well be overcome, so you would get smoke going forward across the ceiling.

MR PUCKRIN: No further questions, Mr Chairman.

MR ANTROBUS: Thank you, Mr Chairman.

MR SOUTHEARD cross-examined by MR ANTROBUS:

MR ANTROBUS: Mr Southeard, also on the question of the smoke. Does a promoted fire tend to generate more smoke or less smoke as a general rule, or are you not able to say?

MR SOUTHEARD: In general terms a promoted fire would be less smoke because it would be a more intense flame and therefore you would get greater combustion.

MR ANTROBUS: So generally it might take longer to detect a promoted fire than an ordinary diffusion fire?

MR SOUTHEARD: That could be true. Yes, that could be true.

MR ANTROBUS: The other thing Mr Southeard, which I wish to ask you is on the question of the door between the passenger section and the cargo hold. You said that it had been open at some stage?

MR SOUTHEARD: No, I said it could have been open at some stage. There was some residue - molten droplets on the passenger side which could have resulted as somebody - or it open and it dripped down on the passenger side. It's the only indication I've got.

MR ANTROBUS: Now do you think that is consistent with it being opened upon impact, or do you think that is consistent with it being opened prior to impact?

MR SOUTHEARD: No. Well, on impact it would - I don't know. I don't know.

MR ANTROBUS: Thank you, Mr Southeard. Thank you, Mr Chairman.

CAPT VAN HEERDEN: No questions. Thank you, Mr Chairman.

MR DONNER: No questions. Thank you, Sir.

MR SOUTHEARD cross-examined by MR VAN ZYL:

MR VAN ZYL: Mr Southeard, could you just explain to us if you have any feel for what size of ignition source we would need to get this fire going? With the emphasis - how small can it be?

MR SOUTHEARD: In my opinion it needs to be of sufficient energy, for example something in a box. I mean a box of something would do it.

MR VAN ZYL: What size of box?

MR SOUTHEARD: Well I just don't know. I can't be that specific.

MR VAN ZYL: And if we look at an incendiary device Sir, have you got any feel for what sort of size of incendiary device?

MR SOUTHEARD: It would depend solely on the incendiary device. I mean how much heat that incendiary device is putting out. I mean a thermite has been suggested but you can't have too big a thermite otherwise you're going to go through the bottom of the 'plane.

MR VAN ZYL: So again could one ask if it's say, a kilogram or half a kilogram of thermite?

MR SOUTHEARD: I would have thought less than a kilogram of thermite.

MR VAN ZYL: Alright, but this is all (indistinct) * ... answer.

MR SOUTHEARD: There's no evidence to suggest what the cargo was. All I'm saying is that I believe it was something in the cargo, whether it was undeclared cargo or

*Indistinct : Speaking simultaneously