MR GREGORY MICHAEL SOUTHEARD duly sworn, states:

MR SOUTHEARD examined by MR CILLIERS

MR CILLIERS: Mr Southeard, what qualifications do you hold?

MR SOUTHEARD: I've got a Bachelor of Science in Applied Chemistry; I'm a Member of the Royal Society of Chemistry; I'm a Chartered Chemist; I'm an Associate of the Institute of Fire Engineers, and I'm a Member of the Institute of Explosive Engineers.

MR CILLIERS: Can you briefly summate your experience in the field of investigating explosions and fire?

MR SOUTHEARD: I was thirteen years at the Metropolitan Police Forensic Science Laboratory dealing with all aspects of Forensic Science. During that time I investigated fires. I also headed a unit which researched into analytical forensic science techniques.

And the last four years, I was heading the laboratory unit for anti-terrorist activities; dealing with all terrorist devices in southern ENGLAND.

I'm now a partner at DR J H BURGOYNE & PARTNERS, and I investigate fires and explosions all over the world.

MR CILLIERS: Can you mention some investigations in which you've been involved for your particular expertise in the aviation field?

MR SOUTHEARD: Well the last ones I've been instructed on are

LOCKERBIE, and I dealt with AIR INDIA.

MR CILLIERS: In your report - we don't have to deal in detail with things which are set out, but we can briefly refer to it. In your report you deal at p 2 with the examination which you made of the recovered debris.

MR SOUTHEARD: That's correct.

MR CILLIERS: And you attach to your report certain photographs to illustrate the points you want to make.

MR SOUTHEARD: That's correct.

MR CILLIERS: Those photographs taken by yourself at the debris centre.

MR SOUTHEARD: Yes.

MR CILLIERS: Now your initial examination was aimed at determining whether or not there was evidence of an explosion...

Explosion

MR SOUTHEARD: That's correct.

MR CILLIERS: ...from the available debris. Did you find any evidence which justified an explosion?

MR SOUTHEARD: No, I was looking initially for an explosion in terms of high explosives; and I found no evidence to suggests that there had been a...

MR CILLIERS: We're not talking about small explosive materials or fireworks, we're talking about high explosive.

MR SOUTHEARD: Detonation, yes.

MR CILLIERS: Detonated and blown the structure of the aircraft apart.

MR SOUTHEARD: That's correct.

MR CILLIERS: You found no such evidence?

MR SOUTHEARD: That's correct.

/How...

CHAIRMAN: How would you define a high explosive?

MR SOUTHEARD: Basically one, Mr Chairman, that produces a shock-wave which is higher than the speed of sound. So you're talking about a detonation of high explosives, rather than a deflagration, which is for example, ignition of petrol in a confined area; that would be classed as a deflagration.

Basically the difference is that you produce a shockwave that travels at velocities higher than the speed of sound.

MR CILLIERS: Now having not found any evidence of an explosion, it was however clear to you that a fire had occurred in the maindeck cargo compartment.

MR SOUTHEARD: That's correct.

MR CILLIERS: And that your investigation then concentrated on determining the degree of heat sustained by the various parts of the aircraft to see what you could make possibly of the cause or causes of the fire?

MR SOUTHEARD: That's correct.

MR CILLIERS: Now as DR FOWLER has explained, the skin of the aircraft was exposed to a cooling affect to a much larger extent than the stringers, and even larger than the frames.

MR SOUTHEARD: That's correct.

MR CILLIERS: So in your investigation about the exposure to heat, did you initially then look at the heat damage to items inside the cargo compartment?

/Yes...

MR SOUTHEARD: Yes, I did.

MR CILLIERS: Now here again, you set out to gauge the lower end of the temperature range experienced within the compartment and so limit the areas which experienced significant heat; so that one could get an idea of where there was a significant heat exposure within this compartment.

MR SOUTHEARD: That's correct.

MR CILLIERS: Did you record the heat damage sustained by reference to items which melt at relatively low temperatures such as the plastic fasteners on insulation blankets?

MR SOUTHEARD: Yes.

MR CILLIERS: And the plastic insulation on wiring and the cable stand-offs and so forth?

MR SOUTHEARD: That's correct, I did. That was the first sort of general pattern which I looked at; was the substances which melted at fairly low temperatures, just to gauge an impression of where the heat had been within that compartment.

MR CILLIERS: Now what was the general pattern of the damage which emerged; where had most of the heat been concentrated, and how far down.

MR SOUTHEARD: It was basically in the crown of the aircraft - the crown of the cargo compartment, the maindeck cargo compartment, and it extended down on the righthand side in the area of stringer 1800/1820.

MR CILLIERS: No, that's body station 1800/1820.

/Sorry...

MR SOUTHEARD: Sorry, yes; not stringer, body station 1800/1820.

MR CILLIERS: And where in the cargo compartment did you find that this significant heat exposure extended the lowest down?

MR SOUTHEARD: Well much in the same way as DR FOWLER has just demonstrated. I carried out a similar survey of the plastic insulation blanket fasteners, and I came to the sort of pattern that you see that DR FOWLER has demonstrated there; coming down in a sort of a V-shaped pattern which centres around about 1800/1820.

MR CILLIERS: At what temperature do these insulation blanket fastener posts melt?

MR SOUTHEARD: The posts melt at about - well, around about 220-250^{o}C.

MR CILLIERS: The report says about 200-250^{o}C; just a wider range.

MR SOUTHEARD: Yes. They do range as you test them.

MR CILLIERS: And in places where these insulation blanket fastener posts had not melted, can one then say the heat had not developed to these temperatures at those places?

MR SOUTHEARD: Yes, that's correct in general terms.

MR CILLIERS: Would that be in the orange area?

MR SOUTHEARD: Yes, that's correct.

MR CILLIERS: We've heard about the level to which the pallets were loaded; we've heard evidence about it and you've actually seen mock-ups of the pallets with

/similar...

similar cargo put onto them.

MR SOUTHEARD: Yes.

MR CILLIERS: To duplicate the cargo which these pallets on the HELDERBERG carried.

MR SOUTHEARD: That's correct.

MR CILLIERS: Was there any area where the - apart from the righthand front pallet where the temperatures in excess of 250°C, had moved below the level of the level of the pallets - the top of the pallets?

MR SOUTHEARD: No, apart from that area the heat damage was minimal or - not below, the heat damage hadn't extended below the level of the top of the pallets apart from that area.

MR CILLIERS: And in that area you say, in the middle of p 3 - that's in that area between body stations 1800 and 1820, that:

> "The blanket fasteners had partially melted down as low as stringer 20 on the righthand side."

MR SOUTHEARD: That's correct.

MR CILLIERS: But that's the lowest point.

MR SOUTHEARD: That's correct.

MR CILLIERS: Now what about the window frames at stringer 20 to 22 on the righthand side; was there any evidence of fire or smoke around the window frames?

MR SOUTHEARD: No, there wasn't.

MR CILLIERS: When one moves aft in the cargo compartment to body station - or after body station 2200, you find

/nylon...

nylon blanket fastener posts there.

MR SOUTHEARD: Yes, there was. In general as you went towards the aft pressure bulkhead, the heat got less. And in fact there were some seals on the aft pressure bulkhead which had melted, but just partially melted; and there were still blanket fasteners on the higher regions of the aft pressure bulkhead.

MR CILLIERS: What maximum temperature prevailed in those areas?

MR SOUTHEARD: Well about 250°C.

MR CILLIERS: You also mentioned the Delrun seals in the rear pressure bulkhead for which the control cables had been routed, had melted and that these melted at approximately 120°C. Where did you get that figure from?

MR SOUTHEARD: I got that from BOEING.

MR CILLIERS: Now that was your general pattern of damage that you could see...

MR SOUTHEARD: That's correct.

MR CILLIERS: ...due to heat exposure. However in areas where materials to which you've referred have melted, that tells you a minimum temperature that was reached. But to obtain a better estimate of the temperatures which were in fact reached, you would have to refer to materials with higher melting points.

MR SOUTHEARD: That's correct.

MR CILLIERS: Can you explain what you did there?

MR SOUTHEARD: I just looked at the general damage; to melting of the aluminium which - other than the skin; so

/aluminium...

aluminium frames and items within the compartment, which were made of aluminium.

MR CILLIERS: And what was the picture that you got there?

MR SOUTHEARD: Basically then it was a V-shaped pattern which came down to again, centering around body station 1800 to 1820.

MR CILLIERS: Then there seem to be two other places. There were some aluminium cable brackets that melted around 1960 to 2220.

MR SOUTHEARD: That's correct.

MR CILLIERS: And there was, in the forward life raft support beam between body station 1680 and 1720...

MR SOUTHEARD: That's correct.

MR CILLIERS: ...there you found some evidence of...

MR SOUTHEARD: Melting on the life raft support beam itself.

MR CILLIERS: Yes; and what about the copper conductors of wiring routed over the forward life raft support beam; what did you find there?

MR SOUTHEARD: There were a couple of conductors - obviously wiring was coming through over the partition between the passenger compartment and the maindeck cargo compartment, and there was wiring across the top of that, some of which showed evidence of arcing. But I believe that was due to attack by the fire. And there was other melting of the copper in globules which I wasn't certain, personally, that it was definitely due to arcing; but I couldn't say one way or the other.

/Further...

MR CILLIERS: Further information which you obtained about the degree of heat to which the skin had been exposed now, you gathered from what DR FOWLER had said and which confirmed - from what he says, confirms that higher temperatures were reached by the skin also between 1800 and 1820, and from stringers R15 upwards.

MR SOUTHEARD: Yes.

MR CILLIERS: Did you have a look at the skin on the outside there? Can you tell the Board what the appearance of that skin was?

MR SOUTHEARD: That had the appearance of being blistered and charred or pyrolysed on the outside.

MR CILLIERS: Now what about the maindeck cargo compartment floor; did that show any sign of fire damage?

MR SOUTHEARD: No, there was no damage either on the floor, except forward of the 9G net. Or, more importantly, beneath it. I mean one of the things I wanted to establish obviously was whether a fire had either come up or spread to the lower load. But there was no evidence of heat damage on the underside of the floor that had been recovered.

MR CILLIERS: That's I take it with the exception of the molten aluminium drops which had fallen from above.

MR SOUTHEARD: Come down; that's correct.

MR CILLIEERS: And of the items which were identified to you as items having come from the lower aft cargo load; was there any sign of fire damage to any of those

/items...

items?

MR SOUTHEARD: No, there wasn't.

MR CILLIERS: The 9G net itself; it was apparently damaged above a certain level, but below about 4 feet - which you show on photograph 21 - had it been heat damaged?

MR SOUTHEARD: No, it hadn't, and there were vertical supports for that which weren't damaged.

MR CILLIERS: Which you can see on photograph 21?

MR SOUTHEARD: That's correct. You can see the four vertical supports, and they're not damaged. And the horizontals are approximately 4 feet from the floor; they are just melted on their top edges.

MR CILLIERS: And is there any evidence of damage to the windows on the righthand side?

MR SOUTHEARD: No, none whatsoever.

MR CILLIERS: So was there any evidence that the fire had burnt on the righthand side, even opposite the righthand front pallet below stringer R15, and any fire damage taking it even a bit lower to R19?

MR SOUTHEARD: No, there wasn't.

MR CILLIERS: You also refer to two struts which you saw further forward in the aircraft. Can you just explain where they were and what you found?

MR SOUTHEARD: These were supporting the central beam which runs along the centre of the aircraft, upon which the stowage bins are supported. And the two struts support this beam from the fuselage. And you can see those in photograph 22 and 23; that's part of

/the...

the beam. I understand those two struts were positioned at body station 1480, and those struts had been heat damaged at their upper ends. So that would have been in an area where they were attaching to the crown of the fuselage.

MR CILLIERS: And the same struts; did they have significantly less damage lower down?

MR SOUTHEARD: Yes, they did.

MR CILLIERS: Well I don't think we have to worry much about the access door; but do you want to say something about the access door between the passenger deck and the maindeck cargo compartment?

MR SOUTHEARD: Only that I believe that it was closed throughout most of the fire, and up until almost to impact - where it was impacted, because the area around the handle and around the trim of the door had been protected by the fire until the last moment when it was pulled away by impact.

MR CILLIERS: Then your report proceeds to deal with the cargo on the cargo list at p 5 and dangerous goods regulations, and cargo handling regulations. Well we don't have to dwell on that, Mr Southeard. One can just say at p 7, you conclude there:

"CARGO LIST"

> "None of the substances listed on the cargo list as having been stowed in the maindeck cargo compartment would in my opinion have reacted with one another to cause a fire under the conditions of stowage in the aircraft.

/Similarly...

Similarly there was nothing listed which would have been prone to self-heating during storage."

MR SOUTHEARD: That's correct. Can I just go back - when I was talking about that access door?

MR CILLIERS: Please do.

MR SOUTHEARD: I don't mean it was closed all the time. There were some drops of molten debris on the passenger side of the door. So it's quite possible it had been opened. I'm not saying it was closed throughout the whole of that fire. All I'm saying is it hadn't been broken into prior to - I mean the reason I particularly looked at it; there was a question of whether somebody had broken into it. I don't believe anyone broke into it.

MR CILLIERS: At p 8 of your report you deal with certain calculations. You refer again to what DR FOWLER has said, and you refer to certain other heat loss calculations which really show the energy which went onto a square centimetre of the skin.

MR SOUTHEARD: That's correct.

MR CILLIERS: And then you say - and this is the point that one could get an idea of the size of the fire one is dealing with in more intelligible terms than so many watts per square centimetre of energy being projected. You say that:

> "Calculations were made to predict the size of a fire which could develop and reach a steady state given the ventilation conditions

/typical...

typical for this type of aircraft."

MR SOUTHEARD: That's correct.

MR CILLIERS: "Based on the ventilation information provided by Boeing, calculations showed that depending on the circumstances, the fire would have reached a steady state heat output from about 250 KW to about 1 MW. This is assuming that 5% of the oxygen in the air was consumed..."

And I'll come back to that. And then you say:

"This size of fire would be equivalent to a fire involving an armchair at the low end or a large settee at the higher end."

Can we just come back to that sentence:

"This is assuming that 5% of the oxygen in the air was consumed..."

Oxygen is about 21%...

MR SOUTHEARD: Yes.

MR CILLIERS: ...of the total amount of gas in the air isn't it?

MR SOUTHEARD: That's badly worded. What I mean is it's reducing the oxygen to 16%. So you've got 21% of oxygen in the air. What I'm saying is, I'm reducing it to 16%.

MR CILLIERS: And then you think that the information which you've got from DR FOWLER and the other calculations you've made, and given the ventilation conditions typical there and assuming that oxygen - of the 21% oxygen in the air, 5% of the 21% had been consumed; one's talking about a fire reaching a steady state of the size ranging from an armchair to a settee, which

/is...

is burning.

MR SOUTHEARD: That's correct.

MR CILLIERS: You then go on Mr Southeard, to consider the origins of the fire, the fire spread, the nature of the fire, and the possible causes of the fire. There were certain features which precluded certain areas of the pallet from being the seat of the fire. Can you deal with that?

MR SOUTHEARD: Yes. There was no evidence of burning around the pallet PR. First of all let me say that I believe that the fire be due to the damage started in pallet PR. Now in order to assess the cause of this fire, I had to look at that particular area. And there was no evidence of burning on the floor around the pallet PR, except at the front of the pallet by the 9G net where you had evidence of molten debris falling down.

From that alone, I tended to disregard carelessly discarded smoking materials. Because in any carelessly discarded smoking materials you would have presumably dropped it on the floor. I think it's very unlikely that anyone would flick it into the pallet. And any fire starting at floor level would have left, in my opinion, burning marks around the area where it started.

There was no fire damage to the window frames on

/the...

the righthand side of pallet PR. And again, I discounted therefore that a fire had started low down on the righthand side, because I believe that any fire in that area would have gone through the very flimsy polycarbonate pull-downs and the acrylic windows, and there was no evidence of fire damage to the windows at all - or to the window frames.

The actual acrylic windows were missing from this piece of debris.

/I also...

I also say that if it started low down on the left hand side of Pallet PR, I believe that it would have involved PL - Pallet PL - at a fairly early stage, and therefore you again would have got collapse, I believe, and burning to the floor between the two pallets.

With regard to the causes I believe - I looked at the electrics in the - within the cargo compartment and the only electrics we've got in that area are raceway H, which runs along the top of the crown, or just to the side of the crown. And in order to get arcing which causes a fire from that raceway, you would have to envisage a braiding of the insulation first of all and possibly - probably - a braiding of two pieces of wire of different electrical potential in order to get the arcing. You would then have to get sustained arcing - in other words the circuit breakers which are rated to blow if you do get short-circuits anyway. You would have to get continual arcing and then sufficient globules of hot iron to come down and ignite pallets, and then you would only ignite those pallets on the top surface. And I just believe this scenario is not feasible in these circumstances.

/You went ...