

and by Captain Johnson as to the verbal content of the RCU briefing was not accepted by the majority of the pilots who attended the briefings. Indeed, there was one pilot who said that upon listening to the evidence given before the Commission in relation to the briefing which he had attended, he was led to wonder whether he had been at the same briefing.

164. The RCU briefing for antarctic flights was primarily inadequate, in my opinion, in that—

- (a) The co-ordination of the United States Navy air traffic control system with the proposed overfly was not properly explained.
- (b) The pictorial representations showed the observers that the flight path was down McMurdo Sound and these displays would, not unnaturally, take precedence over the spoken words indicating a direct track from Cape Hallett to McMurdo Station and indicating the NDB co-ordinates as the destination waypoint.
- (c) The dangers of flying over uniformly white terrain under an overcast sky were not directly referred to.
- (d) The prepared text of the briefing and the constant reference to minimum safe altitudes of 16 000 feet and 6000 feet were verbally contradicted by Captain Wilson in the 1978 and 1979 flights by indicating to the crews that they were authorised to descend to any altitude approved by the United States Navy Air Traffic Controller, and it is significant to point out that at the time when the chief inspector signed and published his report, he had not been told by Captain Wilson, or by anyone else, that this specific authority was orally given to flight crews during the course of the audio-visual presentation to which I have referred. Captain Wilson admitted this. (T. 1236).
- (e) Captain Wilson, the supervisor of the RCU briefing procedures, had not flown to McMurdo Sound. He had applied to go on such a flight, so as to improve his knowledge of antarctic conditions, but his application had been declined by Flight Operations Division.
- (f) Most important of all, crews were not shown a topographical map with the nav track plotted thereon.

THE "WHITEOUT" PHENOMENON

165. The term "whiteout" has more than one meaning as being descriptive of weather conditions in snow-covered terrain. For aviation purposes it is often described as the cause of the visual difficulty which occurs when an aircraft is attempting to land during a snowstorm. As already stated, the United States Navy maintains a special whiteout landing area situated to the south of its normal landing strips near McMurdo Station. This area is used when an aircraft, which is committed to a landing, is required to land when visibility is obscured by a snowstorm. The snow in Antarctica is perfectly dry, and a wind of only 20 kilometres can sweep loose snow off the surface and fill the air with these fine white particles. A landing on the special whiteout landing field can be accomplished only by an aircraft equipped with skis or, in the case of an aircraft without skis, then it must make a belly-up landing on this snow-covered emergency airfield. Flying in a "whiteout" of that description is no different from flying in thick cloud. The pilot cannot know where he is and must land in accordance with strict radio and radar directions. So far as I understand the evidence, I do not believe that either the airline or

Civil Aviation Division ever understood the term "whiteout" to mean anything else than a snowstorm. I do not believe that they were ever aware, until they read the chief inspector's report, of the type of "whiteout" which occurs in clear air, in calm conditions, and which creates this visual illusion which I have previously described and which is, without doubt, the most dangerous of all polar weather phenomena.

166. The chief inspector looked carefully into this variety of whiteout because as his inquiry proceeded it became apparent that although the aircraft was flying in clear air, not one of the five persons on the flight deck ever saw the mountain side with which the aircraft collided. It was quite apparent that the air crew had been deceived into believing that the rising white terrain ahead was in fact quite flat and that it extended on for many miles under the solid overcast. As a result of his investigation, the chief inspector described (at paragraphs 1.17.46 to 1.17.58) the characteristics and the supposed atmospheric causes of this visual phenomenon. His narrative consists of extracts from a special paper prepared on the subject by Robert B. Boswell, an airman who has carefully studied the phenomenon and whose paper is backed by 12 bibliographical references. Here is the opening extract from Mr Boswell's paper, a copy of which was produced as Exhibit 44.

"Whiteout is an atmospheric effect which results in loss of depth perception and is especially common in polar regions when there is snow cover. Only two conditions are necessary to produce whiteout, a diffuse shadowless illumination and a mono-coloured white surface. Whiteout, it must be emphasised, is not associated with precipitation or fog or haze. The condition may occur in a crystal clear atmosphere or under a cloud ceiling with ample comfortable light and in a visual field filled with trees, huts, oil drums and other small objects.

In polar regions these conditions occur frequently. Large unbroken expanses of snow are illuminated by a sky overcast with dense, low stratus clouds that blot out all trace of surface texture or shadow, and merge hollows and snow covered objects into a flattened white background. In addition, cloud and sky may have the same apparent colour, and horizon discrimination is lost and the ground plane disappears.

Those who have not been exposed to whiteout are often skeptical about the inability of those who have experienced it to estimate distance under these conditions, (and to be aware of terrain changes and the separation of sky and earth)."

167. The reasons for the phenomenon are perhaps not of special relevance in the context of the present Inquiry. I am more concerned with the existence and operation of this dangerous visual illusion in polar regions and in all regions where there is snow-covered terrain over which aircraft are required to fly. However, it might perhaps be said that the reason for the disappearance of any deviation in ground level under whiteout conditions is considered by scientists to be due to a complex process of light diffusion. The theory is that a large percentage of the light which penetrates the cloud cover is reflected back from the ground because it strikes the myriads of ice mirrors formed by the ice crystals which are tilted in all directions on the surface of the snow. The light rays are thus deflected upwards and meet the white under-surface of the cloud and then reflect back again. This process of transmission and reflection is believed to be the reason why the forward vista of a uniform white surface, even though quite plainly visible in crystal clear air, will appear uniformly

flat even though the terrain may be undulating or tilted upwards on a steadily rising plane. There have been occasions when this spectacular illusion will prevail even though the foreground, as indicated in the previously quoted extract, contains small dark-coloured objects. But, without doubt, the illusion becomes totally deceptive when there are no dark points in the foreground to afford elements of contrast. Under such conditions aircraft accidents in polar regions and in snow-covered terrain are very common.

168. There was produced in evidence a survey of aircraft accidents in Antarctica during the period when the United States Support Force has been operating there. This is **Exhibit 39**. It analyses aircraft losses in the United States Antarctic Programme from 1946 to 1973. There were in this period a total of 50 aircraft losses in Antarctica and, in a large proportion of cases, these casualties were attributed to loss of horizon or ground definition by reason of the whiteout phenomenon which I have been describing. There were, of course, in addition to the 50 lost aircraft, a great many more incidents in which aircraft were badly damaged. In Mr Boswell's paper, it was estimated that in Antarctica between 1950 and 1960, whiteout was a contributory factor in 40 percent of the 25 flying accidents which occurred during that period. He says that in Canada during the snow-covered months, probably 8 to 10 crashes per annum are in part or completely due to whiteout and that a further 4 or 5 cases per annum of aircraft damage resulting from heavy landings are caused by the same phenomenon.

169. Where there is a solid layer of overcast and snow-covered terrain ahead, then the only effective protection against inability to detect rising terrain will be some large and distinctive dark landmark of either artificial construction or of natural geographical occurrence. In such a case the pilot then has a point of reference which will often, though not always, indicate to him that the apparently flat white ground extending far ahead is in reality on a different plane from what it appears to be. In the case of the approach to Mt. Erebus, there were three possible landmarks which were black in colour and which would have stood out as points of contrast against the broad white slopes of snow which ran upwards towards the peak of the mountain. These points of contrast all consist of areas of black volcanic rock. They are:

- (a) The narrow strips of black rock which appear towards the bottom of the 300 foot ice cliff which marks the beginning of the rising snow slope. They represent areas of rock not covered by the layer of thick glacial ice which covers the whole of the lower slopes of the mountain.
- (b) The rocky outcrop situated about 4000 feet above sea level to the left of the direct approach to the mountain peak.
- (c) The broad exposed rock of "Fang Ridge" located not far down from the mountain peak.

170. On 28 November 1979 there were visible to the crew of TE 901, as the aircraft approached Mt. Erebus, only the narrow strips of rock at the bottom of the ice cliff referred to in paragraph (a) above, and these happened to be on the approximate flight path of the aircraft. The overcast was well below the 4000 feet level of the black outcrop to the left of the aircraft's approach and of course the Fang Ridge, along with the whole of the mountain above 2000 to 3000 feet, was totally obscured.

171. I was satisfied, after hearing the chief inspector's evidence and after studying Mr Boswell's paper (**Exhibit 44**) and the other document (**Exhibit 39**), that the characteristic conditions for whiteout must have existed in the case of the fatal flight. The cloud formation constituted a total overcast on the approach to Mt. Erebus with a base of 3000 feet, which probably gradually descended to 2000 feet or perhaps a little higher as it met the mountain, and seeing that no one on the flight deck ever saw the snow slopes into which the aircraft crashed—not even at the last second with the aircraft flying in clear air—there could be only one conclusion.

172. However, the existence of a whiteout of this kind was evidently not accepted by the Director of Civil Aviation. He declined to accept that there had been a visual illusion of this kind and, as I understood his evidence, he took the view that even if there had existed visual deception of some kind it played no part in the occurrence of the disaster.

173. Under these circumstances, it became necessary for counsel assisting the Commission to make inquiries as to whether there were expert witnesses who could verify or explain the nature of the phenomenon and who, once appraised of the cloud conditions surrounding Ross Island on the date in question, could give an opinion as to whether or not this highly dangerous visual illusion did in fact exist on the day in question.

174. Inquiries were made and Mr Baragwanath was in due course notified that there were three leading authorities on the subject in the United States and one in Canada. As the Commission was obliged in any event to travel to the United States to take depositions from the United States Navy personnel who had been at McMurdo Sound on the day of the disaster, it was arranged that the experts to which I have referred would also be interviewed during the course of our journey. In order to take the opinion of an expert in relation to this type of visual phenomenon, it was necessary to produce all the information which so far had been gathered in the course of evidence in relation to the weather in McMurdo Sound on the day of the fatal flight. In this respect we had at our disposal the following information:

- (a) A photograph of the McMurdo area taken by satellite less than an hour before the time of the crash. This photograph showed the location of cloud formations and the approximate altitude of such formations.
- (b) There was evidence from Flight Lieutenant McLeod of the Royal New Zealand Air Force, who had flown by helicopter from Victoria Land across to McMurdo Station during the late morning of the day in question, and who was able to describe the extent of the cloud cover over Ross Island and the approximate base of the overcast.
- (c) We had evidence in the form of statements from pilots of two United States aircraft which had been approaching McMurdo Station from the true north and true south respectively not long before the occurrence of the crash. These two pilots were able to give a description of cloud formation and cloud layers both north and south of McMurdo Sound.
- (d) There was evidence from Mr J. S. Hickman who is a meteorologist employed by the Meteorological Service which forms part of the Ministry of Transport. He had previously visited Antarctica and is a member of two organisations devoted to scientific research in the Ross Dependency area. Mr Hickman not only gave technical

information as to weather forecasting in general in the Ross Sea area, but he also gave his opinion as to the weather prevailing to the true north of Ross Island as revealed by certain of the passengers' photographs.

- (e) I had available passengers' photographs taken during the last 2 or 3 minutes and up until the last few seconds of the fatal flight.
- (f) There was no one who could describe for me the height of the cloud base to the north of Ross Island, that is, on the line of approach of the DC10. However, I had at my disposal a cloud formation chart drawn up by Mr M. R. Sinclair who is employed as a meteorologist with the New Zealand Meteorological Service, and during each of the 1978-79 seasons he was stationed at Scott Base as part of the New Zealand Antarctica Research Programme. Part of his duties were to conduct research studies of local weather in the McMurdo area. At the time of the disaster he had been at Vanda Station in the Wright Valley, about 130 kilometres to the west of the crash site. Mr Sinclair compiled a reconstruction of weather conditions from all the available information which I have previously listed, including photographs taken by passengers. He constructed a most valuable cartographic profile of the position of various shallow cloud layers in the general location of the two descending orbits of the DC10. His cloud profile indicated scattered thin cloud layers 50 miles out from McMurdo Station, wide breaks in clouds between 60 and 25 miles from McMurdo Station, and then a continuous cloud layer over Ross Island, as from about 10 miles from Mt. Erebus.
- (g) We had the CVR transcript.
- (h) There was evidence which had been given before me by Professor R. H. Day who, since 1965, has been the Foundation Professor of Psychology at Monash University, Australia. He has had particular experience in the field of human perception, in particular with aeronautical research organisations in the United Kingdom and in Australia. He is the author of 125 papers in technical and academic journals in the field of various types of human perception. He is recognised as a world authority in his field.

Professor Day made a close study of the chief inspector's report and made himself familiar with the known factual aspects of the disaster. In the course of his studies relating to the disaster, he discussed all aspects with Dr J. C. Lane who is the Director of Aviation Medicine, Department of Transport, Commonwealth of Australia. Dr Lane is regarded as one of the world authorities on human factors in relation to air accident causation. Dr Lane authorised Professor Day to say that he concurred with Professor Day's proposed evidence. In Professor Day's opinion, it was apparent from a study of the passengers' photographs and Mr Sinclair's evidence regarding meteorological conditions that the necessary conditions for the occurrence of the whiteout phenomenon in fact existed, and he was satisfied that loss of depth perception and lowered threshold contrast existed throughout the final period of this flight. He had this to say, as part of his evidence:

"It cannot be emphasised too strongly that the effects of whiteout are insidious in the extreme. Even on the ground the effects are not recognised by the affected individual until a gross error has been made, such as walking into a snow bank, or falling into a hole. The effect occurs quite rapidly under the conditions of

intense light stimulation and white surfaces above and below. There is no way of knowing the visual system is grossly affected until an untoward event occurs.

I should add that I have not observed whiteout or experienced it in antarctic conditions. However, the conditions for its occurrence are now well established. They can be reproduced in the laboratory, although, there have been no systematic laboratory studies of it. It seems to me that the conditions which existed during the final stages of the flight were sufficient to produce a significant degree of visual impairment when looking ahead from the cockpit."

Professor Day then paid particular regard to what he termed as the "mental set" of the individual who is confronted by the components of visual perception. He considered all the evidence, in particular the misleading track diagrams, which suggested that the crew of TE 901 believed that the nav track was taking them down the centre of McMurdo Sound. He came to the conclusion, having regard to the topographical situation which existed, that a concerted belief on the part of the air crew, reached on the basis of the flight documents in question and by reliance upon the false waypoints, would have overcome any minor features of the view ahead which otherwise might have raised doubt as to whether the aircraft in fact was upon the supposed course. In summary, therefore his view was that the level of efficiency of the visual system of each member of the flight crew was probably markedly degraded through whiteout phenomenon, that is to say, the high intensity stimulation of rebounding light between the white land surface and the cloud above. The main consequence of this impaired visual efficiency would have been loss of contrast sensitivity and greatly impaired depth or distance perception.

In the result therefore, although Professor Day recognised that the whiteout phenomenon might alone account for the failure to ascertain the presence of rising terrain, he placed great emphasis upon the audio-visual briefing and upon the flight documents as being a systems failure on the part of the airline, which played a decisive part in accentuating loss of contrast sensitivity, as revealed by the failure of the flight crew to ascertain that the white expanse of ground in front of them was not on a flat plane as it seemed to be. The professor pointed out that the strongest evidence in support of the part played by the "mental set" was that it was not the visually perceptual system of a single member of the flight crew that failed, but that of five persons, including an experienced antarctic observer and commentator.

175. The total of the information listed above was displayed to each of the expert witnesses whom we saw. The first witness was Dr J. E. Goodson of the United States Navy Base at Pensacola, Florida. Dr Goodson has had 20 years experience in the study of vision as a psychiatric physiologist, and has made a close study of visual perception. Dr Goodson's opinion was that upon looking at the rising snow slope on this occasion, with the sun behind, and total cloud cover above, a pilot could think that he was perceiving an expanse of level ice or snow running forward for perhaps 40 miles. Without texture or contour to guide him, he would see the limits of terrain vision as being far away and not close. This opinion was backed by detailed references to which I need not now refer.

176. Captain Philip T. Briska was also interviewed at Pensacola. He is a flight surgeon and chief ophthalmologist at the Pensacola base. He is also a naval aviator with over 2000 hours spent mainly on fighters. Captain Briska, having studied all the relevant material, was of the opinion that if Captain Collins had believed that he was overflying the sea ice in McMurdo Sound, and that he had in front of him 40 miles of flat ice and snow then, having regard to the weather conditions, he would believe himself to be seeing those conditions as he flew under the overcast towards the snow-covered approach to Mt. Erebus.

177. The next expert we saw was Captain A. P. Ginsburg, who was stationed at the Wright-Patterson Air Field, Dayton, Ohio. Our interview with Captain Ginsburg was highly instructive. He is a special consultant to the United States Air Force on the topic of visual phenomena, and was awarded a doctorate in philosophy by the University of Cambridge in the United Kingdom for his published work in this field. His duties in relation to the United States Air Force are directed towards the special visual problems that may occur in the handling of fighter aircraft travelling at supersonic speeds. Captain Ginsburg's special field is that of contrast sensitivity which exists as a function of sight. He successfully evolved a system of ascertaining by appropriate tests the degree of contrast sensitivity possessed by any person whose sight, as tested by conventional means, is perfect. One of the leading features of his researches has been that of two persons with perfect visual acuity, as measured by conventional means, one may have first-class contrast sensitivity whilst the other has only this latter function in an impaired state. Consequently perceptive ability of each of the two persons, particularly used in relation to moving objects, will vary to a considerable degree.

178. Mr Baragwanath and I demonstrated to Captain Ginsburg a summary of the total information which we had obtained regarding the weather conditions at McMurdo at the relevant time, and he made himself thoroughly familiar with all this information. We also asked him to take into account, but only as an hypothesis, that Captain Collins had flown on nav track southwards from Cape Hallett until orbiting through a cloud break and had armed the nav track again as the last orbit concluded because of his belief that the nav track would lead the aircraft down the centre of McMurdo Sound with many miles of flat sea or ice on either side.

179. I will now set out, in my own language, a synopsis of what we were told. First of all, Captain Ginsburg deferred his consideration of this latter evidence suggesting Captain Collins believed that by maintaining the nav track he would be keeping the aircraft many miles away from any high ground. Captain Ginsburg concentrated his attention upon what the pilot and co-pilot were likely to have seen at the conclusion of the second orbit when the plane was locked back on to nav track as it approached Ross Island. In Captain Ginsburg's opinion, having regard to the known height of the overcast—which, judging by the passengers' photographs was still well above the aircraft at the moment when it struck the mountainside—and having regard to the position of the sun and its 34° inclination, then the pilot would have seen a white expanse of flat terrain extending forwards for an unlimited distance. His point of visual reference would only have been the shallow strips of black rock some miles to the left and some miles to the right of the aircraft, representing Cape Tennyson and Cape Bird.

180. Looking forward, there would be no points of reference over the ice and snow. Not only would there be no points of contrast but there would

be no perception of depth. The fact that the flat white carpet in front was in fact rising upwards at an inclination of 13° and then 19° before meeting the overcast would not be perceived. There would be no shadows and no points of reference to terrain in a forward direction, and Captain Ginsburg expected that a pilot not familiar with this type of visual illusion would merely fly straight on.

181. We referred to the undisputed evidence that no one on the flight deck ever saw the snow-covered slopes into which the aircraft flew. Captain Ginsburg said that this was not a surprising feature at all and indeed he would expect, in the conditions prevailing, that no one on the flight deck, even flying in clear air, would detect that the aircraft was about to strike a rising expanse of white terrain. He said that the only pilot or pilots who would suspect that ocular phenomenon would be people who had flown in polar regions before. He said that pilots with arctic or antarctic experience would also not see the mountainside but, having noted the overcast, would be aware that there might be something in front of them which they could not see. The two or three pieces of rock face in the ice cliff directly ahead of the aircraft would not be identified as anything but thin black strips of sea of the type previously encountered while the aircraft was flying over floating pack ice a minute or so previously.

182. We then asked Captain Ginsburg to consider the factor previously mentioned—namely, that the pilot may have believed himself to be flying over a very wide expanse of flat ice in the approximate centre of McMurdo Sound. Having studied the maps, Captain Ginsburg expressed the opinion that the two thin strips of dark rock to left and right of the approach to Lewis Bay would coincide, in the pilot's opinion, with the entrance to McMurdo Sound, and if the captain's nav track confirmed the pilot's belief that he was in the centre of McMurdo Sound then the totality of the illusion would be complete. He said that the pilot, upon levelling out after the second orbit, and upon looking far ahead along the flat white surface, would be expecting to see the high terrain 20–30 miles away which lies approximately to the true south of the head of the Sound, and when he could not see it he no doubt decided that it was safer to climb away. Overall, Captain Ginsburg was of the opinion, having studied all the evidence which we were able to give him, that the absence of depth and contrast definitions would have produced what he described as a characteristic example of total visual deception.

183. Captain Ginsburg placed very considerable emphasis on the same point as had been made by Professor Day, namely that everything turns on the mental pre-condition of an observer. He stressed that the eye is not a camera. He said that the observation of a particular object necessarily requires a combination of the function of sight with the function of mental activity associated with the process of observation. Discrepancies between what appears to be seen and what is known to be visible are automatically cancelled out by the mind in favour of a picture of what is known to be there.

184. If Captain Collins believed, on various grounds, that he was flying down the approximate centre of McMurdo Sound then he would, as a necessary function of his intellect, relate whatever he saw to what he expected to see, and would co-ordinate objective and subjective perception. But this would only occur if he was certain of his position. If he were in any way uncertain of his position then his subjective perception would be disengaged, so to speak, and he would be guided by visual

perception alone. If certain of his position, and his course, he would automatically discount minor variations in the visual perception as opposed to what he expected to see, but only up to a certain limit of tolerance, that is to say, if visual perception suddenly appeared to present a picture which was markedly different in some respect from his expected observation, then that factor would intrude upon the pre-condition of certainty of position and, for the first time, a state of mental uncertainty would arise as to whether he was in fact upon the course or in the position previously assumed.

185. In this respect, according to Captain Ginsburg, the similarity in the approach to Lewis Bay and the approach to the head of McMurdo Sound had constantly to be borne in mind because, judging from the passengers' photographs, it was in all probability a factor confirming the mental set of Captain Collins that he was certainly in the centre of McMurdo Sound. It seemed clear from the passengers' photographs that the tip of Cape Tennyson, as seen from an approach to Lewis Bay, and the tip of Cape Bird, as seen from the same position, each revealed a very shallow line of black rock surmounted by snow. If the appearance of Cape Bird from the centre of the Sound also presented a narrow strip of black rock at sea level, and if Cape Bernacchi presented a similar picture, then the inequalities of distance would not matter. There would not be any sufficiently obtruding difference from the expected vision sufficient to cause any doubt to arise.

186. Although out of sequence in the narrative, I should here refer to another expert opinion on this topic. On 10 November 1980 we visited Farnborough and, having there listened to a reproduction of extracts from the cockpit voice recorder tape (as elsewhere mentioned), we were asked to see Mr Roger Green who is a psychologist employed in a civilian capacity with the Royal Air Force as a specialist in flight skills, including visual illusion. His attendance is required at about one-third of the Boards of Inquiry held by the Royal Air Force involving incidents in which the presence of human factors appears to have been an operative cause.

187. Mr Green laid stress upon the guides provided by visual cues, and emphasised the point that without visual cues the factors of depth and contrast substantially disappear. He gave by way of example a sudden snowfall over one of the military airfields in England which resulted in three fighter pilots landing well short of a runway of which the location was very familiar to them. What had happened was that the snow had obliterated the visual cues by which they had been guided in previous approaches, and Mr Green stressed the point that in many cases people, and especially pilots, are not necessarily aware of the fact that they are using visual cues so that the disappearance of the latter passes unnoticed.

188. In snow-covered terrain, a pilot is deprived of texture information which will alone acquaint him with slope and distance. In bright sunshine he is only deprived of that information to a partial extent. But even so, his normal appreciation of variation in terrain is adversely affected. Mr Green also stressed the importance of the mental set of a pilot, and believed that Captain Vette's comparison between Lewis Bay and the approach to McMurdo Sound was a good example. That comparison is described in para. 200.

189. Mr Green said that stereopsis and binocular cues are only of help up to relatively short distances, perhaps not exceeding 100 feet or so, and that thereafter perception depends very largely upon experience. It is for

this reason that Mr Green placed the greatest stress upon the principle that there can be no substitute, in the aviation field, for past experience of terrain. An RCU briefing should be confined, in Mr Green's opinion, to purely conventional briefings. It cannot implant knowledge in the memory in the same manner as actual experience. He pointed out that a civil pilot does not often fly purely visually, and Mr Green was of the opinion that when this occurs and a pilot is unfamiliar with the terrain, a number of dangers will instantly arise.

190. The third of the experts whom we were advised to see was Mr G. W. Shannon, Vice-President of Operations for Bradley Air Services Limited of Ontario. Mr Shannon's company flies both passenger and freight schedules up to North Canada and the sub-arctic. He was also retained some years ago to carry out a commercial contract in Antarctica. He flew from the southernmost point of South America across to Shackleton Base in Antarctica, and then across the polar continent to McMurdo. This flight, and other operations in the antarctic, was carried out in a de Havilland twin Otter, Mr Shannon's work being connected with the operations of a United States drilling site. He is reasonably familiar with the McMurdo region by reason of that particular contract which he carried out in Antarctica. Mr Shannon was recommended to us as being an expert whose knowledge and experience of flying in snow conditions is exceptional.

191. We saw Mr Shannon at his company's location at Nepean, some miles out of Ottawa. Mr Shannon had the advantage of having no prior knowledge of the DC10 disaster, except that he naturally knew of the occurrence. He had not read the chief inspector's report, and had no detailed knowledge of the circumstances. Over a period of between 2 and 3 hours we displayed to Mr Shannon all the relevant maps and diagrams, weather information, cloud locations, passengers' photographs and so forth. We also showed him the chief inspector's transcription of the cockpit voice recorder. Mr Shannon noted all this material and paid close attention to the cockpit voice recorder transcript which he read and re-read on a number of occasions, particularly the closing stages.

192. In Mr Shannon's opinion, the prevailing weather and the location of the sun and the other factors previously mentioned would present to the pilot and co-pilot of the DC10 a forward vista of flat snow and ice extending away to the far distance, and he had no doubt that a pilot unfamiliar with polar conditions would believe that he was flying forward with clear visibility over flat terrain for many miles. Mr Shannon believes that the pilot and co-pilot would have therefore an apparent flat and clearly visible terrain definition, whereas in fact there would be no terrain definition at all.

193. We asked Mr Shannon whether the overcast extending forward would form an illusory horizon in the distance at a point where it met the snow-covered rising ground. Mr Shannon said he thought not. He said that in such conditions the almost invariable effect is that the underside of the overcast turns white so that there would be no horizon at all. He said that there was a possibility of a false horizon, but he regarded that possibility as remote. His own years of experience of flying in such conditions led him to the conclusion stated above, namely, that the overcast in front of the pilot would seem to disappear by reason of the fact that its grey undersurface would become white in colour through the multiple light reflection provided by overhead sun behind the aircraft.

194. Mr Shannon gave as an example an occurrence which often takes place at their own airport when the ground is covered with snow. He said that if there is a light overcast overhead then in daylight the underside of the overcast turns white and it is not possible from the ground to discern the height of the overcast. He said you know the overcast is there because you cannot see the sun, but it is not possible to say whether the overcast is 1500 feet high or 5000 feet high when looking upwards from the ground. He said that they are dependent upon reports from pilots as to the height of the overcast.

195. Mr Shannon said that having regard to the known weather conditions which we had exhibited to him, he would expect that as Captain Collins levelled out following the second orbit, and having dropped height to 1500 feet to try and see something in the distance but without success, that Captain Collins would then have elected to climb away because he could not see any landmarks in the distance. Mr Shannon said he noted, from his study of the cockpit voice recorder transcript, that Captain Collins decided, very soon after having levelled out, that he should fly away and he attributed that decision to the fact that although the aircraft was flying under the overcast, and although the ground seemed to stretch away for miles, nevertheless there was no terrain anywhere to be seen.

196. As with other witnesses whom we saw on our travels, Mr Shannon placed primary significance upon the adherence by Captain Collins to the nav track. He said that if Captain Collins had plotted the nav track on a map, then he would obviously have believed that there was no danger of any kind ahead, and that he was many miles away from any high ground. Mr Shannon said that one of the reasons why he had studied and restudied the closing stages of the transcript was to try and see whether there was any expressed concern or doubt on the part of the pilot or co-pilot in relation to the course or position of the aircraft. Mr Shannon was not very interested in the cross-talk which was taking place behind the pilots. He said that he drew the conclusion that neither the pilot nor the co-pilot entertained the slightest apprehension at any stage, and he drew the further conclusion that each of them was perfectly satisfied as to the course and position of the aircraft.

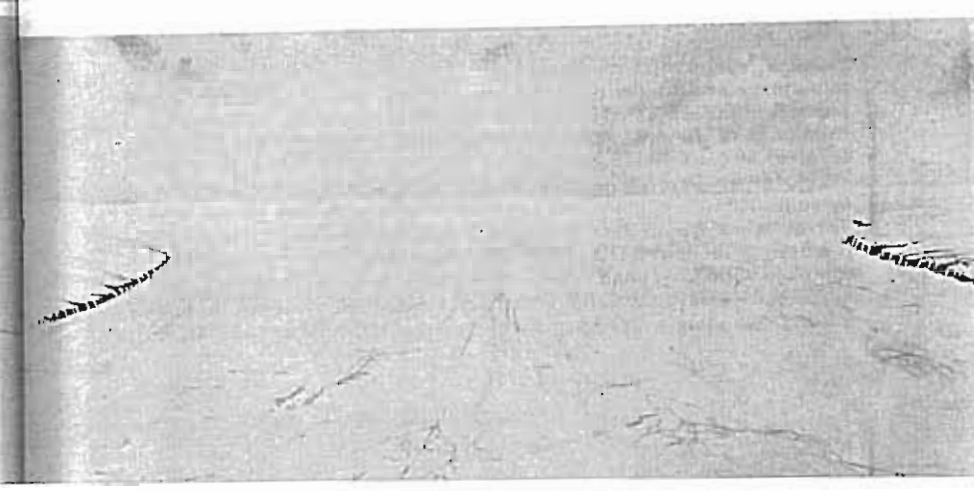
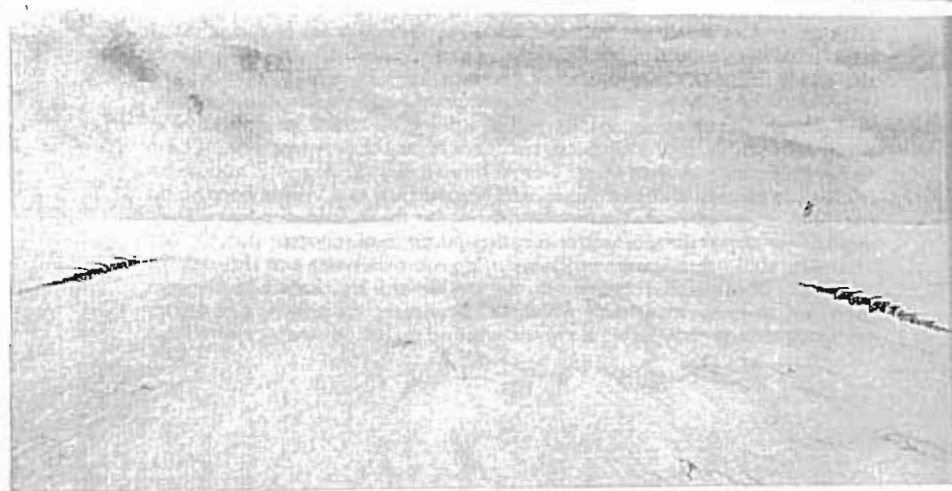
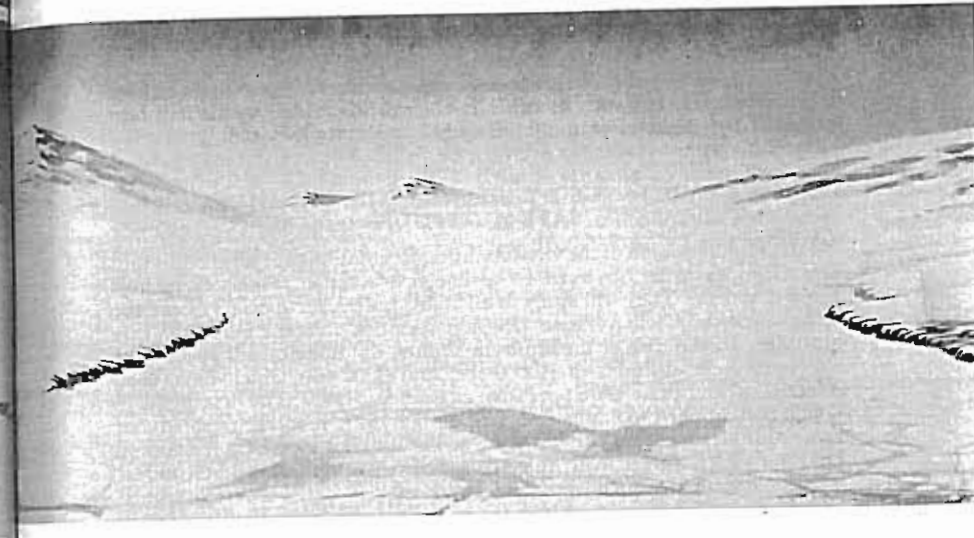
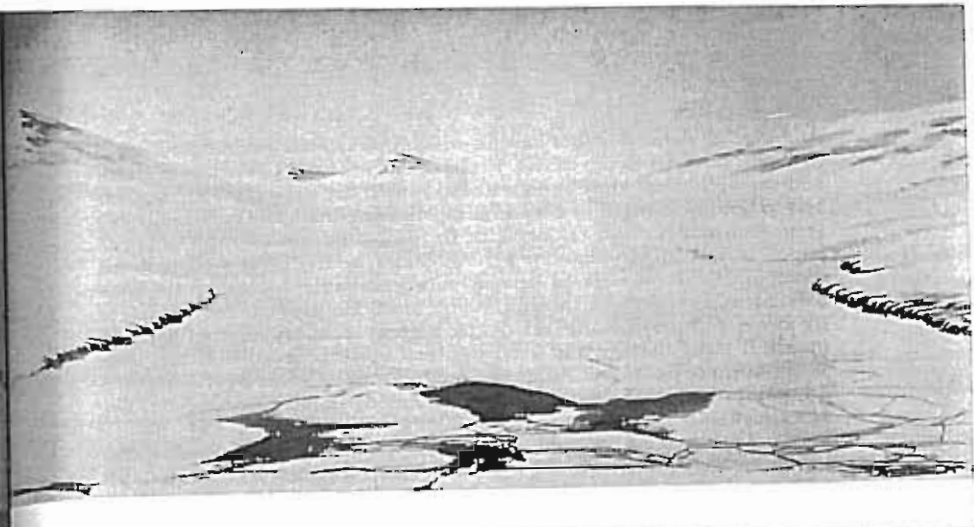
197. We raised with Mr Shannon the theory that a pale fog may have drifted off the ice and covered the ice cliff. We told him that a helicopter which had landed on the ice shelf below the cliff about an hour later saw no sign of the ice fog although it was observed on subsequent days to be coming off the ice. Mr Shannon said that the winds in that area are very fickle, and even a temporary breeze from the true north would instantly form ice fog the moment it reached the ice shelf below the cliff. The fog might persist with a steady breeze, climbing upwards, but if the breeze died away then the fog would disperse. Mr Shannon believed that if there were patches of black rock visible forward of the aircraft on that part of the ice cliff not covered by glacial ice, then this would have no significance to Captain Collins or the co-pilot as, from a distance, any shallow patches of black rock would merely resemble the patches of black water which they had previously observed.

198. Mr Shannon said that the situation confronting Captain Collins as he levelled out after the last orbit would have signalled a red light to the experienced antarctic flier who would immediately have flown away. One of the last passengers' photographs had illustrated that the weather ahead was getting more solid, and in Mr Shannon's view any experienced pilot

would have realised that conditions were no longer appropriate for VMC flying. But Mr Shannon again pointed out that it had taken Captain Collins only a brief interval to reach that conclusion, and he had then attempted to fly away once he could not discern the clear visibility which Mac Centre had told him would be apparent once he had descended to 2000 feet. Also, the two or three last passengers' photographs were printed off film which had been damaged by light, and the indistinct view revealed by prints would not have been the actual view.

199. It remains now to summarise the effect of all these inquiries on the facts of the present Inquiry. Cases of aircraft flying directly into snow-covered terrain in clear air, but with an unbroken low overcast, have been so numerous in aviation history as to be a matter of common knowledge among pilots who fly at low altitudes in polar regions and in northern Europe and Canada in the winter months. As I have had occasion to say already, the occurrence of this insidious and dangerous phenomenon is known and respected by all pilots accustomed to flying in such conditions. Neither Captain Collins nor First Officer Cassin had any experience of flying at low level over snow. Their long experience of flying DC10 aircraft had been confined to the temperate zones. There can be no doubt, upon all the evidence, that after the DC10 had descended in clear air and levelled out at about 3000 feet, it was still flying in clear air with unlimited visibility all around. As the aircraft approached the entrance to Lewis Bay, the cloud overhead ceased to be scattered and became a solid pale grey overcast. The pilots saw to the left the low rocky shoreline of Cape Tennyson and believed it to be the western coast of Cape Royds. On their right, some miles away, they saw the low black shoreline of Cape Bird and just above it, under the overcast, the sun shining on the snow-covered slopes of Mt. Bird. They believed they were looking at Cape Bernacchi on the eastern side of McMurdo Sound. In addition they had the remark, which in my opinion was made by Mr Mulgrew, pointing out that the Taylor Valley was on the right. Mr Mulgrew was looking at the cloud-hidden area just past the Cape Bird shoreline and believed that he was looking just past the Cape Bernacchi shoreline where the Taylor Valley begins.

200. It had been my intention during the hearing to ask for an artist's impression of the comparison between the entrance to Lewis Bay, as revealed by the passengers' photographs, and the entrance to the head of McMurdo Sound as represented by Cape Royds on the left and Cape Bernacchi on the right. But I found that Captain Vette had thought of such a presentation himself, and in fact he produced sketches and photographs as Exhibits 233 and 234. For the purposes of this report I have had them modified, and checked against a verified survey profile of the two entrances. The mountain features are not exactly to scale, the purpose being only to give a representation of each entrance in clear air, then in air partly obscured by either ice fog or cloud, and finally, in conditions where a low overcast entirely covers the forward area. These three stages are shown as to Lewis Bay in fig. 5, page 72 and as to McMurdo Sound in fig. 6, page 73. The presence of a visible horizon on the final stage of each figure should not be taken into account. They appear in the representations for the purpose of clarity, but as Mr Shannon said, there was probably no visible horizon on the day in question. The visual references thus established by the air crew were therefore in conformity with what their maps were displaying to them. Looking ahead, they saw the pure white expanse of snow-covered ice



running up to the 300-foot ice cliff which marked the commencement of the snow-covered slopes of Mt. Erebus. The presence of the low overcast and the uniformly white surface ahead caused the snow cliff to disappear and to become merged in a featureless white expanse. The crew may have seen a distant horizon (as depicted in the bottom photograph of fig. 5, page 72) but in Mr Shannon's view, and I attach great weight to his opinion, the snow-covered terrain most probably blended with pale overcast so as to make no horizon visible at all. Captain Collins decided to fly away, and the obvious lack of any urgency surrounding that decision makes it clear that he and First Officer Cassin believed that they had many miles of flat ice on either side and in front of them. By the time the ground proximity system suddenly sounded, nothing could save the aircraft.

201. I have dealt with this "whiteout" phenomenon in considerable length for the simple reason that this disaster transcends in magnitude all past examples of aircraft disasters caused by whiteout phenomena. If the veil of cloud had parted, even for a second, and provided a fleeting glimpse of the mountainside, then the aircraft and all its occupants could at the last moment have been saved. Without the whiteout phenomenon, the mistake made by the Flight Operations Division would have been discovered, because Mt. Erebus would have appeared in the direct path of the aircraft, but as events turned out, the mistake, aided by the weather, deceived the flight crew until the end.

COMPLIANCE BY PILOTS WITH MINIMUM SAFE ALTITUDES

202. Regulation 38 of the Civil Aviation Regulations specifies minimum safe altitudes to be observed by airline operators in respect of various types of terrain. They will apply to all flights unless, for special reason, the Director of the Civil Aviation Division specifies different minimum safe altitudes. In the case of the antarctic flights, the director did specify the minimum safe altitudes of 16 000 feet and 6000 feet which have been referred to, and these were operative as from mid-1977. The first flights to which they applied took place on 18 October 1977. It will be recalled that these altitudes were suggested by the airline and not by the Civil Aviation Division which agreed with the two suggested minimum safe altitudes.

203. Captain Gemmell who commanded the first of the antarctic flights, and Captain Grundy who commanded the second, each testified that at no time did their flights go below 16 000 feet in the McMurdo area. In respect of each flight there was evidence which suggested the contrary, but I am not going to take up time by discussing that evidence now. I am primarily concerned with flights from 18 October 1977 onwards, to which minimum safe altitudes of 16 000 feet and 6000 feet at all times officially applied, in the sense that no descent below those altitudes, under specified conditions of descent, was permissible without the prior consent of the Director of Civil Aviation.

204. There were pilots who did not interpret the 6000 feet MSA as meaning what it appeared to say. They believed it was restricted to a "cloud break" procedure and that it was permissible, in appropriate conditions, to descend below 6000 feet so long as regulation 38 was complied with. On behalf of the airline and on behalf of the Civil Aviation Division, it was naturally contended that there was no room for misunderstanding with regard to the extent of the 6000 feet limitation. It

was however susceptible, as I read it, of the interpretation placed upon it by the pilots to whom I have referred. But again I do not propose to go into this matter of misinterpretation of the 6000 feet MSA because I consider that it has no real relevance to matters which I am called upon to investigate.

205. In the first place the evidence makes it clear, in my opinion, that all Antarctica flights from and including 18 October 1977 involved a let-down in the McMurdo area to altitudes considerably less than 6000 feet, and that in the main the flights down McMurdo Sound and across the Ross Ice Shelf to the south of Mt. Erebus were conducted at altitudes ranging from 1500 feet to 3000 feet. There was one flight which diverted to the South Magnetic Pole and in this case the question does not arise.

206. The next point is whether the occurrence of flights in the McMurdo region of less than 6000 feet was known to executive pilots of the Flight Operations Division and to the management sector of the airline. Captain Lawson was called to give evidence on behalf of the airline. He had been, as will be recalled, the first supervisor of the Route Clearance Unit and he had been co-pilot of the first flight. He also flew as co-pilot with Captain Hawkins on the third flight which took place on 18 October 1977, this being the first occasion upon which the 6000 feet limitation was operative. In the course of his evidence, Captain Lawson said that although Mac Centre invited Captain Hawkins to descend below 6000 feet, that invitation was declined. In cross-examination, Captain Lawson was referred to **Exhibit 83** which is an extract from a copy of the *Auckland Star* of 22 October 1977. This is an article written by a Mr Graeme Kennedy. The article describes the progress of the flight of 18 October 1977 and it contains a reference first to the aircraft flying over Scott Base and McMurdo Station "at less than 2000 m.". Later in the text the following passage appears:

"At the controls Captain Hawkins brings the DC10 down to 200 m over Scott and McMurdo Bases—well below the towering volcano Erebus belching smoke only 40 ks. away."

207. Mr Henry, cross-examining on behalf of the passengers' consortium, told Captain Lawson that Mr Graeme Kennedy had been interviewed and had indicated that the reference to 200 metres ought to have read 400 metres—in other words, approximately 1300 feet. Mr Henry asked Captain Lawson for his comments. Captain Lawson maintained that Mr Kennedy's report was inaccurate and that "to the best of my recollection" the flight did not descend below 6000 feet. Captain Lawson admitted that Mr Kennedy was personally known to him. The point of this cross-examination was to show that there had been published in the *Auckland Star* on 22 October 1977 a press report indicating a low-level flight down McMurdo Sound with Mt. Erebus 40 kilometres away.

208. During the course of further cross-examination, Captain Lawson was asked whether he was aware of any other written reports referring to flights in the McMurdo area at below 6000 feet. Captain Lawson said that he had read a copy of **Exhibit 148A**, which is a Newsletter published by the airline and entitled *Air New Zealand News*. The article in question is dated 30 November 1978. It consists of a brief description of the flight to Antarctica of 7 November 1978. The opening two paragraphs of the article read as follows:

"The flight deck crew of TE 901 took the boss flying with them on November 7.