

APPENDIX H
BOARD RELEASES AND PRESS STATEMENTS

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APOLLO NEWS CENTER
HOUSTON, TEXAS

NEWS RELEASE NO. A13-10
APRIL 17, 1970
SUBJECT: APOLLO 13 REVIEW BOARD

The National Aeronautics and Space Administration today established an Apollo 13 Review Board to investigate the circumstances and causes of the accident aboard the spacecraft Odyssey and the subsequent flight and ground actions taken to recover.

This action was taken by NASA's Administrator, Dr. Thomas O. Paine, and Deputy Administrator, Dr. George M. Low, immediately following the successful recovery of the astronauts today "because of the serious nature of the accident to the Apollo 13 spacecraft which jeopardized human life and caused failure of the Apollo 13 lunar mission."

Mr. Edgar Cortright, Director of NASA's Langley Research Center in Hampton, Virginia, was appointed Chairman of the Review Board. Mr. Cortright served for many years as NASA's Deputy Associate Administrator for Space Science and Applications, and in 1967-68 was Deputy Associate Administrator for Manned Space Flight.

The other members of the Board will be senior individuals from NASA and other government agencies with special competence in flight safety matters, the Apollo systems, or the various technical disciplines related to the investigation, but not having direct responsibilities relating to Apollo 13. Top consultants from government, industry, and the academic community will also be available to the Board as required. NASA's Aerospace Safety Advisory Panel, a statutory panel responsible to the Administrator, will review both the procedures and findings of the Review Board and make an independent report to the Administrator.

The Apollo 13 Review Board will establish its own procedures as provided by standing NASA instructions for the investigation of mission failures. The timing of its report will be determined after the Board has met and made an assessment of the length of investigation required. The Board will make periodic progress reports directly to the Administrator and Deputy Administrator. Timely progress reports will also be made to Congress and the public.

NASA's Office of Manned Space Flight will make available to the Review Board all pertinent records and data and will provide technical support to the Board as requested. The Office of Manned Space Flight,

as a part of its regular responsibilities, will develop parallel recommendations on corrective measures to be taken prior to the Apollo 14 mission.

Decisions on the Apollo 14 mission will depend on the findings and recommendations of the Apollo 13 Review Board, the Aerospace Safety Advisory Panel, and the Office of Manned Space Flight.

APOLLO NEWS CENTER
HOUSTON, TEXAS

NEWS RELEASE NO. A13-10

APRIL 18, 1970

SUBJECT: UP-DATE TO STATUS OF APOLLO 13 REVIEW BOARD

The Chairman of the Apollo 13 Review Board, Mr. Edgar Cortright, Director of NASA's Langley Research Center, expects to discuss with Dr. Paine and Dr. Low on Monday the appointment of additional members of the Board established to review the accident to the Apollo 13 spacecraft. The Board will meet as soon as possible — very soon, Mr. Cortright said — to set up its procedures and begin its investigations.

APOLLO 13 INVESTIGATION BOARD REPORT NO. 1
APRIL 21, 1970

DUFF: Ladies and Gentlemen, this is a briefing by Mr. Edgar M. Cortright, the chairman of the Apollo 13 Review Board. Mr. Cortright.

CORTRIGHT: I thought that it would be beneficial if we got together for a few minutes today to give you some idea of how this Review Board will be conducted, and to announce the members of the Board. The membership has just been selected by Dr. Paine. Basically, as you know, from the material you've received already, and to paraphrase my detailed instructions, the function of the Board is to perform an independent assessment of what happened, why it happened, and what to do about it. To do this, we have selected a group of senior officials from both within the agency and without the agency. These gentlemen will meet here with me during the next few weeks in intensive sessions, which will probably run days, nights, and weekends, without letup, in order to get an early determination. The group will be supported by an additional group of experts, and we will select these gentlemen within the next 2 or 3 days. In addition, we'll draw on the work that the project is now carrying out under the direction of the project manager to determine on their own what happened. Now, the members of the Board are as follows: Mr. Robert Allnutt, who is assistant to the administrator in NASA Headquarters; Mr. Neil Armstrong, astronaut, from the Manned Spacecraft Center; Dr. John Clark, Director of the Goddard Space Flight Center; Brigadier General Walter Hedrick, Jr., Director of Space, Deputy Chief of Staff for R&D office, Headquarters, USAF, Washington; Mr. Vince Johnson, Deputy Associate Administrator for Engineering, in the Office of Space Science and Applications, NASA Headquarters; Mr. Milton Klein, Manager of the AEC-NASA Space Nuclear Propulsion Office; and Dr. Hans Mark, Director of the Ames Research Center.

QUERY: How do you spell that last?

CORTRIGHT: Mark. M-a-r-k. In addition, the counsel, legal counsel, for the Board, will be Mr. George Malley, who is Chief Counsel for the Langley Research Center. Mr. Charles Mathews, Deputy Associate Administrator, Office of Manned Space Flight, will be named to work with the Board to help provide the technical support we'll need to get our job done. In addition, there will be three officially named observers to the

Board. Mr. William Anders, former astronaut, now Executive Secretary, National Aeronautics and Space Council; Dr. Charles D. Harrington, Chairman, NASA Aerospace Safety Advisory Panel, and also President and General Manager of Douglas United Nuclear Incorporated; and Mr. Irving Pinkel, Director, Aerospace Safety Research and Data Institute, Lewis Research Center. We'll be assisted in our relationships with the press by Mr. Brian Duff of the Manned Spacecraft Center. And we'll be assisted in our relationships with the Congress, during the course of this investigation, by Mr. Gerald Mossinghoff, Office of Legislative Affairs, NASA Headquarters. It will be our policy during the course of this investigation to keep you informed of what we're doing, and how we're going about our business, insofar as that is practical. One thing I'd like to avoid, however, is speculation. I must avoid that with this type of a Board. So, if sometimes I appear to be not as communicative as you would like, it will only be because I'm not in a position to say something with authority and certainty, at that time; but otherwise we'll do all we can to keep the members of the press fully informed of what we're doing. And, I think that is about all I really planned to say. I make myself available for questions within the ground rules that I just specified, that I'd like to avoid speculation, and further, since the Board has not held its first meeting, I can't very well represent the Board at this point.

DUFF: I'd just say one thing, before we have questions. The biographies of all the members and the documents relating to what Mr. Cortright has just said will be available after this conference is over. Now we'll take questions.

QUERY: Can I add one point, Brian? I think I forgot to mention that the first meeting of the Board will take place at 8:00 p.m. this evening.

DUFF: All right Bob, we'll start across the front row.

QUERY: I realize it's impossible for you to say precisely how long the Board will take to reach the determination, but do you have any estimate at this time? In other words, would it be a matter of perhaps 3 or 4 weeks or do you think it would last through the summer?

CORTRIGHT: It's my hope that we can reach adequate and effective determination within 3 or 4 weeks. As a matter of fact, that is the number I had in my mind. But we'll have to take as much time as required to do it properly. It could run longer.

SPEAKER Bob.

QUERY: What procedure will you follow for calling perhaps contractor experts and so on? Can you - you said you would talk about them a little bit.

CORTRIGHT: Yes, we identified the need for speciality information that's best developed by a contractor. We'll call on that contractor to provide us information and/or to appear before the Board to testify on this information.

QUERY: Do you have any names or companies already formulated?

CORTRIGHT: No.

QUERY: What is going to be the possibility, Ed, on making your releases? Are you going to do it on a regular basis like once or twice a week, or just whenever you have something to say? How are you going to arrange this?

CORTRIGHT: The releases of the Board will be made only with my approval and through the office of the Public Affairs here at Houston. Now there may, of course, be releases by Dr. Paine or Mr. Low based on information that I can provide them on regular meetings. We'll probably meet once a week. And I would envision the use of bulletins for the press. How much information they would contain would be dependent on how much progress we will make. But at least it would keep you informed on where we are and what activities are facing the Board that week.

QUERY: Do you intend to break the Board down into teams similar to what was done for the 204 Review Board?

CORTRIGHT: That's my current plan. But until the Board meets with me and expresses their individual opinions and negotiate a little bit, I won't know for certain.

DUFF: Here.

QUERY: Ed, when will you have all the telemetry data reduced, do you think, with the Board then in a position to move at full burner?

CORTRIGHT: Well, the telemetry data are being reduced at the moment by a pretty sizable team of engineers, both here and in the contractor's plant. I don't have specifics on that yet, Jules, but I have the impression that they expect some

milestones to be reached before the end of the week, in terms of telemetry data reduction. Of course, that's sort of first time through, perhaps, and we'd have to iterate that to get the last little bit out of it.

QUERY: Was consideration given to appointing Lt. Gen. Sam Phillips to the Board?

SPEAKER: I'm not certain. Dr. Paine selected the Board. I know General Phillips is extremely busy with his present assignment and it probably would be an impossibility.

DUFF: Right here, Mary Bubb.

QUERY: When you finally do pinpoint the cause, sir, how long do you think it will take you to decide whether you have to go into redesign or some modifications? I would presume anyway that you would make recommendations along these lines.

SPEAKER: Well, of course that depends on what the problem is. Generally speaking, you work on potential fixes at the same time you're homing in on the probable cause, so that there need not necessarily be a long period of time between the two, the determination of the problem and what to do about it. On the other hand, there could be under certain circumstances, and my position at the moment is that I can't - I have a totally open mind. I'm trying not to prejudge anything. As the facts unfold, then we'll start forming opinions.

DUFF: Ed.

QUERY: Two questions: I assume that the bulk of the investigation will be conducted here at MSC. Is that correct?

CORTRIGHT: That is correct.

QUERY: And what will the relationship be between your Board's investigation and the investigations already underway by individual contractor teams and by the initial review board that was set up right after the accident? And what is the status of that board, by the way?

CORTRIGHT: Well, I'd rather not comment on the status of the Manned Spacecraft Center Board. That's Dr. Gilruth's board, but I can tell you a little bit about how we plan to work together. In the first place, most of the detailed technical work will have to be done by the men who know that area the

best, and these are the engineers and scientists of the Manned Spacecraft Center and the prime and supporting contractors. We will follow their work and audit their work and make the best possible use of their work that we can. At the same time, we'll maintain sufficient independence so that it will constitute a true independent check on what's done here and an independent assessment of what corrective measures should be taken. Does that answer your question?

QUERY: Mr. Cortright, in your experience have you ever conducted a similar investigation having to do with unmanned spacecraft, trying to find out what happened?

CORTRIGHT: I have not chaired a board of this type, but I've been involved in a number of investigations of various unmanned spacecraft projects, such as Ranger, Surveyor, and Centaur.

QUERY: What was your rate of success in these investigations?

CORTRIGHT: Well, all of the projects that I mentioned succeeded to a rather high degree. The extent to which the review board helped that process is something we'll probably never know.

DUFF: Here in the front row.

QUERY: Will your reports - your periodic reports to Dr. Paine be released to the press?

CORTRIGHT: Probably not.

QUERY: Will we know that there are these reports and will we even know the gist of them, if you're making progress, or stymied, or what?

CORTRIGHT: Well, as I mentioned earlier, we will try to keep the press informed as to what's going on with the Board, but we'll stop short of speculating or prematurely judging the results. That, of course, is quite a constraint in terms of making public what our current opinions are as to what happened, and I think we'll be fairly limited on what we can say until this job is done. Now, my reports to Dr. Paine will be informal progress reports and will contain just the sort of material that it would be improper to release in totality because it's somewhat speculative in nature. I don't think you'd really want that any more than I would.

QUERY: Ed, I'm not quite clear on this point. You may have made it clear and I may have slipped in a cog. Does - is corrective work, such as deemed necessary by various groups here at MSC or the Cape, or wherever else it might be, is corrective work suspended or held in abeyance while the Board meets? For example, if it were found that the liquid oxygen tank, for example, was suffering from stress corrosion or metal fatigue and blew at too low a pressure, and Beech or North American or somebody wanted to go ahead developing new tanks, would that effort go ahead in tandem with the Board's investigation or be held up for the Board's findings?

CORTRIGHT: I'm not positive, but I believe the procedure that would be followed would be that a major corrective work which might impact the existing system and result in changes to hardware that's currently assembled would be held in abeyance until the Board's report was in. On the other hand, it is not unreasonable that certain things could go forward in parallel for possible incorporation later in order to save time now.

QUERY: Dr. Cortright, does your franchise possibly extend to the early shutdown of the second stage engine, and second question, is it likely that you would make any recommendations on the deployment of rescue ships in the Atlantic or even possibly the Indian Ocean?

CORTRIGHT: The instruction does not require us to examine the early shutdown on the second stage engine except insofar as the peak g loads might have influenced the anomaly we're looking into. I don't anticipate that we will be considering deployment or any other aspects of rescue ships.

QUERY: Along the same line, it is in your charter to examine the adequacy of the measures taken in Mission Control to see whether there are some improvements that could be made in those or whether that response could be improved in any way. That is still your understanding?

CORTRIGHT: Yes, sir. That is in the charter, the instructions.

DUFF: Thank you very much.

APOLLO 13 INVESTIGATION BOARD REPORT NO. 1
APRIL 24, 1970

CORTRIGHT: I indicated the other day when we talked that I'd keep you abreast of what we're doing and although I think what I have to say is less than you want to hear, it's a progress report at least. I thought I'd start out by telling you how we've organized to do the job. There was a little indication of that the other day, but this is the structure of the Review Board. This is the Board itself, and I went through those names the other day. Now, in addition, we have four major panels. One is on Mission Events, and this panel is chaired by Frank Smith from NASA Headquarters. In addition, we have asked that Neil Armstrong from the Board have a secondary function of following in depth the activities of this particular panel. The panel will have three members: John Williams from Kennedy Space Center, who will handle preincident events as to the events up to the time of the incident; Tom Ballard, from Langley Research Center, will handle the events of the incident in detail — the short period of time in which the apparent explosion took place; and the postincident events will be handled by Pete Frank, and he is from Houston Manned Spacecraft Center. The second panel is Manufacturing and Test. Schurmeier from the Jet Propulsion Laboratory will handle that, and Jack Clark, the Director of the Goddard Space Flight Center, will be the member of the Board who stays with that panel's activity when he is not meeting with the Board. That panel will also have three members: Ed Baehr from the Lewis Research Center, who will review the fabrication and acceptance testing of the hardware that flew; Karl Heimberg from the Marshall Space Flight Center, who will review the subsystem and system testing of the qualification-type testing; and Brooks Morris from the Jet Propulsion Laboratory, who will look into the reliability and quality assurance aspects of the hardware. The third panel, on Design, will be headed by Mr. Himmel from the Lewis Research Center, and Mr. Johnson of the Board will honcho that activity with him. Now the one member, Dr. Lucas from Marshall, who has been identified to work on failure modes and mechanisms, will also be a design evaluation man and a man to look into related systems, so that if there is a lesson in here to be learned which can be interpreted and applied to other systems it will be his responsibility to understand that. The last panel is on Project Management. Ed Kilgore from Langley Research Center is the Chairman there, and Milt Klein from the Board will work with him. There are three men who will help, a Mr. Ginter from NASA Headquarters,

Mr. Mead from the Ames Research Center, and Mr. Whitten on safety from the Langley Research Center. That group will, in general, look into the management aspects of the procurement of this hardware and its preparation for flight to see if there were any breakdowns in the system we've been using which may have been contributory. Now, although I haven't shown you this chart before, there are some staff boxes that we don't have to spend any real time on. The first one I mentioned the other day — that's a very important box actually. Mr. Mathews is heading up the OMSF Technical Support. That is, he's insuring that the Board gets everything it needs down here. And he's also working on how to interface with the investigation that's going on by the project, and just how do our members of the panel work with their counterparts in the Manned Spacecraft Center and the contractors who are really looking at the same questions. We have a council secretary to handle our records and papers, a Report Editorial Group, I think I mentioned that the other day, to lay out the manner in which we'll report this to Dr. Paine, Public Affairs, and Legislative Affairs, Mr. Mossinghoff. We've had one addition to the observers, Mr. Wilson from the House Committee on Aeronautics and Space, Congressman Miller's Committee.

CORTRIGHT: Now, that is the essence of what I wanted to tell you today. We're getting into the problem in some depth. We've been going through that period when everyone who starts to look at the data immediately invents his own explanation and has to discard it the next day. So, it's sort of a "getting humble" period, and I think we're almost through that, and we're starting to get our hands really dirty and understand what went on. I'm not prepared to issue any statement on that subject today, but I would ask you whether or not — or I might point out, rather, that there was a statement issued in Washington's part of the committee — the testimony of Mr. Petrone before the Congress today, which gave the timeline of significant events or the major events leading up to the incident. Have you all had a chance to get that yet?

SPEAKER: I believe so - -

CORTRIGHT: Well, it may be more current. I'll be glad to quickly read it for you if you'd like. The first event at — this is eastern standard time 10:06, oxygen fans were turned on. At 10:06 and 22 seconds, it was a high current spike in fuel cell number 3. At 10:06 and 36 seconds, there was an oxygen tank number 2 pressure rise. At 38 seconds, there

was an 11.3-volt transient on ac bus number 2, at 41 seconds, a high current spike on fuel cell number 3, and at 58 seconds, an oxygen tank number 2 temperature rise. At 10:07 and 45 seconds, oxygen tank number 2 maximum recorded pressure, and at 10:07, 53 seconds, there were measurable motions of the spacecraft. At 10:07 and 56 seconds, the oxygen tank number 2 pressure went to zero, and shortly thereafter Lovell stated that he had a problem. Additionally, Mr. Petrone made the following statements: "That the event was not a meteorite. The probability was calculated to be too low, for one thing." And also, "The telemetry is good enough and the number of events have enough information in them that it would appear not to be that rare coincidence of a meeting with a meteorite." He goes on to say, "From preliminary examination, it does appear that the observed rapid rise in the oxygen tank number 2 pressure would require an amount of heat much greater than that produced from current flow for the tank fans, heaters, and instrumentation operation. In other words, the electrical system could not alone pump enough heat into that — energy into that tank to raise the temperature of the oxygen as — and the pressure of the oxygen, rather, as much as was observed. This does not rule out electrical power as a source of initiation for some other energy source as yet undetermined. Analysis and tests are being made to determine what such an energy source could be and how it could have been initiated." That's all I have to say.

QUERY: I'd like to ask you a question about what Dr. Paine said this morning. He referred to it as a relatively simple component in the number 2 oxygen tank, and he seemed to think the problem could be taken care of right away. Could you comment on that? What is this relatively simple component?

CORTRIGHT: Well, here's what he said: "The oxygen thermos flask believed to be involved is a relatively simple component, and corrective action should not prove to be a major task." I think he was referring to the entire tank and its contained equipment as being simple. And I think what he — I'll speculate here — that he means it's simple compared with the rest of the system, and even if they had to do major things to that tank, that it probably could be done in time not to impact the schedule. But, I don't think he was precluding the possibility of some fairly major changes in that tank. But, the tank itself, you know, is a reasonable-sized device to have to cope with.

QUERY: Then you see possibly some major changes that will have to be done in the tank for Apollo 14.

CORTRIGHT: I wouldn't rule that out.

QUERY: Cortright, have you seen any indication at all which would give you a clue or a vague hint as to what possibly could have gone wrong? Anything at all to lead you into a general direction?

CORTRIGHT: Well, the obvious. If you're looking for energy in a tank like this, you have to say, "Well, what energy is there to start with?" And, you do have kinetic energy, you have moving parts, namely, the fan and the motor that drives it. And, you have electrical energy. You do know that there were glitches in the electrical system which would lead you to think there might be some electrical problem in the tank. And, it's not very mysterious, really. You can get short circuits with electrical equipment, and they usually are accompanied by glitches. So, that's certainly one possibility that would have to be considered.

QUERY: You didn't mention fires. Was there any danger of fires?

CORTRIGHT: Again, the major energy source, potentially in the tank, would be combustion, and if combustion took place, it's not certain exactly what it would be like with super-critical oxygen at those pressures and temperatures and the small amount of combustible material in there. We don't quite know what it would be like if it happened, but it could happen conceivably, and that could have been the energy source.

QUERY: Mr. Cortright, is there anything that you have eliminated as — besides the meteorite — as not being the cause?

CORTRIGHT: Now, we're not really going at it that way, yet. Now the Board has started by concentrating on that area that the experts here had determined as the probable source of trouble. And, we've spent most of our time trying to get to understand everything about that oxygen tank; how it interfaces with the rest of the equipment in the system; what energy sources are there in that tank and how might they be triggered; what type of chemical reactions could take place in the tank; would they look like combustion or not, and how might they be initiated? So, we are not really yet concentrating on ruling things out. We're trying to rule things in right now.

QUERY: Mr. Cortright, do I interpret that to mean that Mr. Petrone's statement today was his own; it was not based on anything the Board of Review had said? It was based on the MSC investigation? And, let me ask you further to follow Paul Recer's question, have you ruled out a meteorite?

CORTRIGHT: We haven't considered it abort yet, but I'm inclined to say "Yes." The odds would be extremely small that it could be that. As far as Petrone's statements are concerned, I'd say they are his own, and the way we're handling this sort of thing; statements of fact, insofar as they can be determined to be fact, are made by the Project. And, we draw on those same facts to help us in our investigation. So, in other words, if you have detailed questions about how vague were the current spikes and exactly when they occurred, the Project is releasing all that information as fast as it can pin it down. And, the interpretive part of it, apparently, they are releasing some of that too. I'm trying not to do too much of that now.

QUERY: Have you ordered any tests such as the effect of the electrical arc within this tank or some to that effect? Any tests using - -

CORTRIGHT: Tests are already under way by the Houston team. They are trying to determine in what way an electrical problem might have been a source of ignition, for example.

QUERY: To follow that question, have you ordered or requested that Houston investigators or any others go further in their investigations in any direction than they have been going and are you generally satisfied with those investigations?

CORTRIGHT: Well, I've been generally satisfied. We have made a suggestion or two which would constitute slight expansions to what was already being done, but generally, we've been satisfied.

QUERY: You listed some possible or potential causes that are being investigated. I wonder if you could run through a complete, you know, 1, 2, 3, of the possibilities that will come into consideration without weighing them in any relative value.

CORTRIGHT: I'd rather you get that from the Project.

QUERY: You plan to meet as -- in panels and perhaps one or two executive sessions a day.

CORTRIGHT: We do that. Generally speaking, we meet with Jim McDivitt and his people at 8 o'clock in the morning, to start the day off. And we get a summary of what they accomplished the day before. Then we have special technical briefings as we need them in the morning and otherwise operate as panels and subpanels during the balance of the day. We also monitor the technical meeting that takes place every evening at 6 o'clock, Mr. Arabian's meeting.

DUFF: It would make my life a little easier if you'd say what you plan to do over the weekend. If you don't, I don't have to.

CORTRIGHT: Well, if you know, I wish you'd tell me. We will work over the weekend, but at the moment, most of our days aren't planned very far in advance. We're still playing it by ear as we go along.

QUERY: Sir, I've been told that there's a report at Cape Kennedy that one source of the problem is thought to have been a motor driving fan which failed. That it's the motor driving the fan that failed. Is this true, or do you know?

CORTRIGHT: Well, that — the fan motor and the fan does constitute the kinetic energy you have and also constitutes a major electrical element, one which does use a fair amount of current. Yes, that's under close examination.

QUERY: Did it fail?

CORTRIGHT: No. I didn't say that. I'm sorry. I guess I misunderstood your question. It could have failed. It could have been the source of the problem. It's one of the potential sources.

QUERY: Do I understand correctly that there's no doubt whatsoever that the problem occurred within the tank?

CORTRIGHT: No. It's highly likely. According to the project here, the project office, that the problem occurred within the tank. And frankly, the evidence we've seen so far, also points in that direction. We haven't come up with anything different.

QUERY: Will telemetry tell you whether this fan motor failed?

CORTRIGHT: Telemetry may. There was a loss of some telemetry, as I guess you know, something like 1-1/2 seconds, and it may be possible to get a little more data out of that lost telemetry, which would help determine that problem.

QUERY: And do you still think that you can conclude this in 3 or 4 weeks?

CORTRIGHT: I think it's possible. It looks tight.

QUERY: Well, in order to do that, wouldn't you have to know where you're going?

CORTRIGHT: Yes. And that's why I said we haven't yet. Of course, we've only been here a couple of days — a few days, but we haven't yet seen any anomalies in the mission that point elsewhere. Everything points to this tank. So we're concentrating on understanding every possible failure mechanism of the tank.

QUERY: Are you as optimistic as Mr. Paine was this morning? He seemed to be rather optimistic that everything would be cinched up pretty fast and Apollo would be back on schedule very soon. Are you that optimistic?

CORTRIGHT: I think it should be possible to fix this tank up. Yes. But I — you know, when I look at a tank like that, I think, well, there's a good job here to be done, probably, and it will take some effort. But it's not as big an effort as these people have handled many times before.

QUERY: Talking about something as basic as a fan motor, all the other tanks have fan motors, don't they? Or are there - -

CORTRIGHT: There are other fans and other systems I believe, yes, that will have to be looked at.

QUERY: Does your data indicate there was a fire on board definitely and if so, what size fire?

CORTRIGHT: No. That conclusion has not been reached. All it indicates is that there was some source of energy in the tank large enough to raise the pressure above that possible with just plain electrical omni heating.

QUERY: Would you, in reference to that, that list you have there, indicate the 1-1/2 second data dropout?

CORTRIGHT: Well, the dropout occurred just at the time of the incident. In other words, when the apparent bang took place that's when they lost the data.

QUERY: How's that indicated on that list?

CORTRIGHT: I guess it isn't.

QUERY: Do you have a time for it?

CORTRIGHT: You can get that from the Project Office.

QUERY: Combustion in a tank would infer the presence of a contaminant, would it not?

CORTRIGHT: Not necessarily. Combustion can be different things, of course. Oxidation — rusting is combustion, you know, in a sense. So what we want to understand is if there was combustion, what was it that was oxidizing and how was it going about. It wouldn't have to be a contaminant. There are other things in the tank that could react with oxygen and metals and insulation, both.

QUERY: Dr. Cortright, when you say within the tank, you mean inside the sphere now. You're not talking about equipment associated with the tank or near it. You were talking inside the sphere of the tank.

CORTRIGHT: That's correct.

QUERY: I understand there's paper matting insulation between the two walls. Is this being left out as the possible source of combustion?

CORTRIGHT: Yes. I don't know whether it's paper or not. There's superinsulation in there. At the moment, the Board is concentrating and looking at the inside of the inner sphere, both the insulation on the wires and the possibility of contaminants and some of the metals themselves.

QUERY: You also plan to look between the two walls?

CORTRIGHT: We'll have to look at all that.

QUERY: — metal could react with the oxygen could you characterize that? The nature of the reaction that the metal prepared — you're not speaking about combustion in there are you?

CORTRIGHT: Yes. Aluminum can burn, and liquid oxygen under the right conditions.

QUERY: Blaze sort of thing?

CORTRIGHT: I don't know too much about that yet. I'd just as soon not try to answer that question. As you know, aluminum can burn in air.

QUERY: Is the Project Office or industry, or anyone else simulating any failure modes and if so, what are they?

CORTRIGHT: The Project Office and North American are both attempting to generate failure modes which could explain all the anomalies in the telemetry. And I refer you to the Project Office for the details of that.

QUERY: In reference to the picture that was released, could you tell very much from that picture what had happened?

CORTRIGHT: Not at first glance. But there are image enhancement experts working on the pictures now to try and get more out of them. In other words, it was difficult to tell much about the number 2 oxygen tank.

QUERY: Is there anything you detected in the photos that would indicate a fire? Any charring or that sort of thing?

CORTRIGHT: No, not to me but there was some staining as you recall that was announced by the astronauts themselves. A brown stain on the outside and I don't know what that means. That's being looked at.

QUERY: Would liquid oxygen itself leave a brown stain?

CORTRIGHT: I haven't any idea.

DUFF: Thank you very much.

APOLLO 13 PRESS CONFERENCE WITH DR. GEORGE LOW
MAY 1, 1970

DUFF: Press conference this afternoon with Mr. George Low, Deputy Administrator of NASA.

LOW: Good afternoon. I have just spent the day since early this morning receiving my first status report from the Apollo 13 Review Board. I received briefings this morning from Mr. Cortright, who is Chairman of the Board, several members of his panels, and also from Mr. Scott Simpkinson and Col. McDivitt and Don Arabian who are conducting the Apollo Program Office investigation here at the Manned Spacecraft Center. There is a major effort on the way, as all of you know, to determine the cause and the possible fixes for the Apollo 13 accident. I don't have an exact number, but I would estimate that between two and three hundred people are working on the problems associated with this event. We do have excellent telemetry data, and a great deal of information from the spacecraft about the sequence of events that occurred on April 13, about 55 hours into the flight of Apollo 13. And as we said before, the major source of information is the telemetry data. We also have photographs of the service module taken after the service module was jettisoned just before reentry. And as of today at least, the information given by these photographs is still inconclusive. Specifically, there is still no firm decision based on the photographs as to whether the oxygen tank number 2 was still in the service module at the time it was jettisoned or not. Review work is on the way in enhancing the photographs, getting the maximum possible information out of them, but it is certainly not clear that we will ever get that answer from the photos themselves. In addition to the telemetry and the photograph, there's also on the way now a very significant effort of tests and analyses. And it will take a combination of all of the data from telemetry, from all of the testing of all of the analytical work, and perhaps information from photographs to determine the most probable cause or causes for the event that took place on April 13. But from what I've heard today, and from what I've been told previously, I'm fairly confident, quite confident that we will be able to bound the problem, that we will be able to determine its limits, and that we will find corrective action that will encompass all possibilities. Both the Board and the project people told me today that the most probable sequence of events on Apollo 13 was as

follows. First, a short circuit occurred in oxygen tank number 2. This short circuit most probably caused combustion within the tank. This in turn caused the pressure and a temperature within the tank to increase. The tank then ruptured. This rupture of the tank caused the pressure in the compartment in which the tank is located to increase which then caused the panel, the big covering panel in the service module, to blow off. And if at any one fact then that I had not known before today is that the blowoff of the panel most probably was when the panel flew off and then hit the high gain antenna which temporarily knocked it out for a matter of a second or two and this led to the loss of data for that very short period of time just about the time that the panel did fly off. We also discussed today the preflight events that might be of importance in connection with the Apollo 13 accident. These included the facts that the motors, the fan motors, the fans inside of the tank were changed early in the manufacture at the vendor's plant; later on the tank, itself, was removed and reinstalled; moved from one spacecraft and installed in spacecraft 109 and during the removal from spacecraft, I believe it was 106, it was jarred or dropped an inch or two, and this may or may not have had an influence on the well-being of the tank. Finally, during the loading and unloading of the tank during the countdown demonstration tests at the Cape, there was an anomaly which made it very difficult to get the oxygen out of the tank. This was several weeks before the flight and a new procedure, not previously tried, was used in this detanking. These three factors are also being looked at by the Board and by the Review Team to see whether there's any possible connection between those and the accident, itself. The Board, today, estimated that they will make their final report to Dr. Paine and myself about the first of June. This is a very brief summary of our discussions today. I also spent time this afternoon then with Dale Myers and Rocco Petrone and Jim McDivitt and discussed possible alternatives of design changes that might be made to the spacecraft without in any way prejudging what the conclusions of the report would be. But no decisions in any such changes have been made at this time. Be glad to answer any questions you might have.

DUFF: We'll start with Art Hill and then go back.

QUERY: George, how certain can you be that a short circuit was responsible for initiating this series of events?

LOW: As I said, Art, the conclusion by the Board and the Review Team was that this was the most probable initiative of the events. I don't think that anybody, as of today, can be positive that this was the — that this will be the final answer, but, as you know, there were a number of electrical glitches, high currents, low voltages, just preceding the rest of the events and the investigation today was focusing in that direction.

DUFF: Ed DeLong.

QUERY: In what component would you estimate that that short circuit happened and when you say combustion in the tank, does anyone yet have any idea of what combustion in a high pressure LOX tank is?

LOW: First question, what component — what component did it happen on. Short circuit could only be in the wiring leading to the fans, to the temperature sensor, to the quantity gage or to the heaters. Now the preliminary conclusions today are that the heaters were not powered at the time, so they're eliminated. And the current to the quantity sensor and to the temperature fills were so low that they are unlikely components. So the most likely source would be the current to the fans.

QUERY: Before you go further, you say wiring leading to the fans. Would that include wiring in the fan motors themselves?

LOW: It could certainly include that, yes.

QUERY: What component reacted or where was — where did the combustion take place?

LOW: Again, the people have looked at what might burn in this oxygen environment, and it would have to be the insulation on the wiring or the wires themselves or some of the aluminum components.

DUFF: Paul, you had one.

QUERY: Have you all simulated this failure with the tank rupturing, and if so, does it cause shrapnel that would damage other components in the same bay?

LOW: The complete simulation — there has been no complete simulation of the tank rupturing or of the entire events in the full-scale tank, and it is certainly not clear today whether the tank would rupture or whether it would spring a leak or whether it would open a small hole only. I was told today that all possible tests are still being examined and that no firm test plan has yet been developed. Again this will depend in part on the analyses and part in the small scale tests and part of it is also the — of looking at the data before the people here will come up with a plan for an overall test program.

QUERY: Dr. Low, you indicated that during the countdown demonstration tests at the Cape that there was what you said was an anomaly which caused difficulty in detanking the O₂ tanks. The other two factors were physical factors like a fan changed or dropped. This is a procedural change. Would you explain how that could possibly be a contributory factor to the series of events?

LOW: Only in that it may — well, first of all it may have — going back to this prelaunch event now, the — at the time that it was difficult to detank the oxygen, an analysis was made and it was concluded that there could have been a buildup of tolerances between various types in the stand-pipe and the vent line that could have led to this difficulty in detanking. In looking back over the records, one can then ask the question could the detanking difficulties be an indicator of something else being wrong inside that tank, and we don't know today that it was. Also, could the specific procedures in the detanking have caused something else to be damaged? For example, during the detanking the gaseous oxygen was pumped into the tank and released again, and the heaters were turned off and on. These procedures are now being examined in detail by the Review Teams and by the Board to see if any of it could have had an effect on the tank itself.

QUERY: George, at what point in the history of the tanks were the fans changed and why were they changed and was it both fans we're talking about or just one or what?

LOW: At what point in history were they changed? Before the tank was delivered to North American, I believe, so while they were still at Beech. They were changed, I believe, because there was a reading of voltage or current or something that was not completely within specifications, so they were removed and a new set of fans was installed.

QUERY: So the fans that were in the tank that the explosion occurred in were new fans?

LOW: As far as I know, that's right. They are not the original fans that were removed at the vendors.

QUERY: The old fans weren't fixed and then put back in, or anything like that?

LOW: I don't believe they were.

QUERY: Sixty-six are we not - -

LOW: I don't know the date, but I would imagine it was at least that early.

DUFF: We could help perhaps afterward by going back and finding some of these. Do you have a question?

QUERY: Two or three here. One, do you have any idea what combustion would be — I mean, would it be flame, what would the physical process of combustion be under those high pressure or low temperature liquid oxygen conditions? Two, yesterday we received from, I gather Jim McDivitt's group, although it came out through the Public Affairs Office and was not tagged specifically as to who it came out through, very firm assurances that, although the shelf had been dropped an inch, this did not contribute to the problem and you seem less certain of that. Could you explain that a little bit, and has there been any speculation at all about what might cause a short circuit and what do you mean when you say short circuit; do you mean two wires crossing, do you mean something stalling the motor and overheating it, what's included there?

LOW: To the first question, do you remember it? Okay, what is combustion like in that environment, its supercritical oxygen at minus 150 degrees and 900 pounds pressure. I really don't know. We had an interesting discussion about this at lunch time, whether — I asked whether we had ever seen or been able to take pictures of something reacting violently in that environment. And I was told no, we had not yet, at least the people here had not seen this, and we are going to look at the possibility of putting a window or a port into a test model so that one can take films of this. So combustion really means a violent reaction, release of energy of so many Btu's which are needed then to increase the pressure and the temperature. I don't think

anybody today can really answer that question in any more detail. The second question concerned the — I try to point out here the three things that we discussed that were anomalous in the preflight situation. The fan change and the removal of the oxygen shelf, and the 2-inch drop that was involved there, and third, the detanking. And I brought these out only because they are unknowns today; I mentioned also that at the time that the shelf was removed and was dropped a couple of inches there was a normal discrepancy procedure followed; in other words, it was examined and was looked at, it was analyzed and the conclusion reached at that time was that certainly the tank was all right to reinstall, where it would not have been done. What the people are now beginning to do is take a look at this again, to reanalyze what might have happened at that time, to see whether higher loads could have been imposed on it than was known at that time, to see whether anything else could have happened that was overlooked at that time. And I mention it only in that light. And if — do I have them all?

QUERY: What do you mean by a short circuit?

LOW: A short circuit means an abnormal flow of current which could be caused by insulation missing off the wire, or the wire touching the ground or it could be almost anything.

QUERY: Does that include the fan motor stalling?

LOW: My recollection from previous knowledge I have had is that the fan motor even in the complete stalled condition will not generate enough heat to cause any kind of a problem.

DUFF: We will get Jim because we haven't gotten to him yet, then we are going to Washington for a few questions, then we will come back.

QUERY: Will any or all of the fixes that you have discussed delay the launch of 14?

LOW: I don't know. I think the important thing here is to fix what went wrong. I should have mentioned, of course, that everybody here is also looking at all the many other possibilities in many other areas where similar or related events might occur. So we are going to take whatever time is necessary to make right what went wrong, and until I get the complete Board report, and this may not even be on June 1st, this was the estimate today, if they need more time, they

will get more time to do their job, and until the job is done both by the people here at MSC and by the Board, we won't really know whether or not we will delay Apollo 14.

DUFF: We are ready for questions from Washington now.

SPEAKER: Okay, please wait for the mike now. Don.

QUERY: George, could you tell us when and where the tank jarring occurred?

LOW: Where and when the tank jarring occurred; it occurred at the North American Rockwell Factory in Downey. And it therefore occurred before the spacecraft was delivered. We will have to get to the exact date; I don't have it. I am told November 68.

QUERY: George, could you tell us -- you were speaking of separating the oxygen tanks takes some equipment change to do that. Are you also thinking -- 1 to 3 months in this whole thing?

LOW: I missed the middle part of the question. Could you repeat it please?

LOW: Could you repeat the question, please. I did not get it.

QUERY: George, are you thinking of separating the oxygen tanks some physical way, not putting them into a different bay, but maybe armor plating them? Are you also thinking of removing the fans and the heaters and any other source of electricity, and if you are thinking of this, wouldn't this mean a delay of anywhere from 1 to 3 months in Apollo 14?

LOW: First question concerned the separation of armor plating of the tanks. This is being looked at also, but it is as of today not proposed as a solution. The removal of fans, specifically the removal of fans, and the changing of the wiring to the heaters instead of removing them or even the possibility of removing them is being examined by Jim McDivitt and his people. Again, no decision has been reached. As far as time is concerned, I cannot give you an answer. I know that there was a time when we launched Apollo flights on 2-month centers and made some very major dramatic changes in those fairly short periods of time. As I said before, we will take whatever time is necessary to fix it.

DUFF: All right. I am told that October is the correct date.

QUERY: Dr. Low, while you were talking about the change and relocating them and so on, you discussed something in general about what design modifications you talked to Jim McDivitt and also what area is it you're looking into where you could through a single event lose your safety redundancy other than the - -

LOW: I can answer the first question. The design changes today are the only design changes. They have not yet moved out on any hardware changes. The design changes that are being looked at include the removal of the fans, the changing of the heater wiring, or the heater location so that all of the wiring into the heaters can be enclosed in a metal sheath going to the outside of the tank. The relocation of the quantity probe or the redesign of the quantity probe to remove the aluminum in it, and at the same time make it possible to assemble the heater and probe device without needing flexible wiring leading to them. And the removal of all nonmetallic materials from inside the tank, and the removal of aluminum and anything else that may react with oxygen. Now, again let me emphasize that these are changes that were being discussed and not yet being perused at North American. At the same time as looking at these and other changes and until all these get together, no decision has been made on any changes.

QUERY: - - some of the possible errors where you could lose your redundancy.

LOW: This we did not discuss today.

QUERY: Did you say McDivitt has some people looking into those other possible areas?

LOW: Yes.

QUERY: - - yesterday that after they're manufactured the oxygen tanks were rejected two times before hastily being accepted on the third inspection as the deadline approached. Would you comment on that?

LOW: This is the first time that I've heard this. We'll certainly look into it and get you an answer. I have no information on this.

QUERY: Well, I'm kind of confused on this fan. When you changed out these fans, did you put back new ones of the same model or were they different models, different in design than the fans that had flown on all the previous Apollos?

LOW: The fans in Apollo 13, to the best of my knowledge, were the same fans that we had flown in previous Apollos. The fans that were removed from the tank back at the vendor's plant apparently did not quite meet specifications when they were tested in the tank. They were rejected, removed, and other fans of the same kind were reinstalled.

QUERY: Okay. Did this happen in any previous Apollo flights, that you had to remove the fans?

LOW: If it did, it was not discussed today.

QUERY: Dr. Low, again along with Paul's question, could you compare these anomalies with anomalies of similar nature of other Apollo flights? Have you had things of this nature happen on other flights that you might be able to compare with the anomalies on 13?

LOW: It's hard to form a comparison. We had, of course, some anomalies in every Apollo flight. None of them was as critical, none of them could potentially lead to as catastrophic a result as the anomalies on Apollo 13 could have led to. Going back in history, of course, we had Apollo 6 where we lost 3 engines on the Saturn V launch vehicle on the way out and had a very — had the POGO problem on the first stage and also had a very major damage to the service module LM adapter. Apollo 7, I don't remember the list. We did lose, during the flight of Apollo 7, momentarily all ac power as you'll recall. Apollo 8, we had very few, although the list of details was quite long still. Apollo 9, you're making me go back in memory here, but we had some kinds of problems in every flight, up to and including the computer alarms on Apollo 11 and the lightning strike on Apollo 12, but none of them, as I mentioned before, were potentially as catastrophic as these might have been on Apollo 13.

QUERY: Well, I was basically thinking that — not of the overall flight but on the LOX tank itself. If you could compare all of the Apollo LOX tank situations, what would 13 look like? Would it look like really a bad tank and if you'd have compared them all would you have gone with it?

LOW: I can't answer that question. It is not at all unusual to have countdown problems or countdown demonstration problems and — because this is why you conduct a countdown demonstration in the countdown. I remember in Apollo 9 we had a very significant problem the entire night before launch on the supercritical helium tank where we did not know whether we had a blockage in the tank or not, and we decided at that time that we were satisfied that we understood the problem as we did on Apollo 13 on the oxygen tank, and went ahead with the launch. That's a related problem in that they were both cryogenics that we had a problem with and only in that sense. I don't think you should consider any single countdown problem or a single countdown demonstration problem or a single check-out problem at the Cape to be unusual. We've changed engines, we've changed fuel cells, we've done all of these things and that's why you conduct tests at the Cape. It's only today in retrospect, now that we've had the accident, we're looking at the procedures again, that we're looking particularly at the procedures in connection with that tank to see whether that could have had an effect on what happened later in the flight.

QUERY: If you're moving the fans from the tank, what mechanism would be used to stir that oxygen? The second thing, what is your opinion now of the possibility of flying another Apollo flight this year?

LOW: The first question is a technical one and even that does not have a complete answer, Jim. Based on information by Jim McDivitt and his people to date, it is possible that we can conduct the flight without stirring the cryogenics with the fan. This is based on looking at all the information from all of the Apollo flights to date and looking at the times and the fairly long times that we've gone on some of these flights without turning on the fans, it appears to be possible to eliminate the fans entirely without replacing them with anything else. This is not yet a firm conclusion. What is the probability of an Apollo 14 flight this year? I can't give you an answer.

QUERY: You talked about the possible design changes in the hardware. How about design changes in the flight, itself, the trajectory and the use of this hardware. Specifically, there has been a suggestion that you might possibly carry the ascent stage back as a possible lifeboat. Is there any consideration being given to design changes in this area?

LOW: That was not discussed today and has not been discussed with me at all, so I really can't answer that. I don't know whether or not it is being considered and if it is being considered, whether it has a positive outlook or not.

QUERY: Dr. Low, based on the thinking of your investigative Board that it can have a final report ready for you and Dr. Paine by June 1st. Does this mean that you have arrested a prime suspect and now you're just going to give the guilty party a fair trial the rest of the month, or have you got some other —

LOW: That's a good way of putting it. No, I told you all that I know. However, the people here are quite confident, that given another week or two of proceeding with the analysis, of doing some of the tests that are underway, that they will have enough information to bound the problem to decide on the design fixes. Now, it may be, as I said before, that they will not be finished by the first of June or it may be that they will give a report on the first of June and we'll ask them to reconvene in July or August or some other time to again look at what has been going on within the Program, and to make sure that all the loose ends, if any, will clean up.

QUERY: Among the possibilities of solving this problem, have you considered any that are not directly related to the structure itself, such as carrying another set of bottles or dividing them into two small bottles, or carrying a reserve supply somewhere else so that a flight would not be impeded?

LOW: Yes. I listed, a moment ago, those avenues that the project people here are looking at most seriously, today. They, then, have a whole list of other things that they are also looking at which include, perhaps all of them that — all of the ones that you have mentioned.

LOW: Have it one at a time, Ed.

QUERY: Okay. You reminded me when you mentioned the POGO problem and the engine failure that we did have an engine-out on this flight and that I have heard some project people say that if there is a delay in 14 that the fixes for that engine-out may be more responsible for it than any modes to the spacecraft. What is the status of that engine situation and how accurate is that assessment of the possibility of delay?

LOW: Ed, I know that people at Marshall are working very hard on that. I have not been briefed on it, and I have not reviewed it, and I honestly don't know.

DUFF: Thank you all very much.

APOLLO 13 REVIEW BOARD CONFERENCE
JUNE 2, 1970

CORTRIGHT: Good afternoon. The purpose of this particular conference is to bring you up to date on where the Apollo 13 Review Board stands, tell you a little bit about why we've delayed our report and a little bit about what our prospects are of making the current date. Now, in particular, I want to tell you something about the tests that are going on. I will refer to a few notes here in which I hope I didn't leave anything out. First of all, let me say that the general status of the review is that it's nearing completion. I'm generally satisfied with the results that have been turned up in the investigation to date. I think the understanding of the accident is good. We've delayed the report, as I mentioned in a bulletin which came out within the last few days, because there are critical tests being carried out which will help pin down some of the details of what took place. The Board has not been satisfied until recently that these details were pinned down. There are still a few key points to clear up.

Now, the tests that are being carried out are being carried out all over the country. For example, here at Manned Spacecraft Center, there are a number going on. They are also being conducted at Ames Research Center, Langley Research Center, Marshall Space Flight Center, Kennedy Space Center, and at North American Rockwell, Beech, Boeing, and a few other places. One of the key tests is — one series of tests relates to this special detanking procedure, which you heard about before, and the checkout proceedings at the Cape prior to launch. Now the tests so far have found the faulty thermal switches, or the failed thermal switches, which were mentioned the other day. They've also demonstrated that if these thermal switches had failed as we now are relatively certain was the case, that the temperatures that would have been reached in the heater tube assembly could have exceeded 1000° F in some spots, although not everywhere. There were tests conducted here at the Manned Spacecraft Center that showed that when the heater assembly, the heater tube assembly, reached temperatures like that it baked the Teflon-coated wires and destroyed the insulation. And a little bit later I'll show you some samples of this insulation and what happens to it when it's baked in an oxygen environment. Now the clincher is going to be conducted at Beech Aircraft Corporation this week wherein an actual flight tank will be cycled back through

the same series of detanking operations that took place on the oxygen tank no. 2 from Apollo 13. These tests began yesterday with a normal detanking and will proceed now into the special detanking. Following the tests, the tank will be disassembled and the wiring damage examined.

Another series of tests that are appearing important are being carried out at the Manned Spacecraft Center, the Ames Research Center, and the Lewis Research Center relate to the ignition and combustion processes in the tank. Now the first tests on ignition of Teflon by means of an electric arc were run at the Ames Research Center; they demonstrated very low ignition energies. In fact, the initial test indicated less than 1 joule of energy and the short circuits that were measured in flight showed energies of at least 20 times that — 10 to 20 times that. Subsequently, the values required to start an insulation fire in the tank fluctuated a little bit, but generally seem to show 1 joule or less minimum energy, if the fire or ignition were by means of an electric arc. Just plain heating takes a lot more energy, but an electric arc concentrates the heat. The most recent test at Ames has shown that if the wire is baked in an oxygen environment and damaged, it still ignites and burns much as if it were in its original condition. Now, the test at the Lewis Research Center was designed to check these phenomena in a zero-g environment. Now, the way this is done is that there's a facility at Lewis which consists of a tank which is dropped from a 500-foot tower. Actually, it's dumped into a 500-foot hole and I think you can get 5 seconds of zero-g flight that way, and if you toss it up from the bottom and let it get almost to the top and come back down again you can get 10 seconds. Basically what they've shown in the combustion rate or propagation rate tests is that in one-g the rate of propagation of combustion along a Teflon-insulated wire depends on whether it's traveling up, down, or sideways because of the convective currents. The direction which most nearly simulates zero-g is down, and that is about twice the rate that really takes place in zero-g. These are just rough numbers, but they are generally right and all of this information has been determined since the beginning of this test program.

As far as the tank rupture is concerned, there has been a lot of question about just how much of a rupture it was, and the guesses have ranged all the way from a small half-inch hole, which might have occurred if a conduit burned out at the top of the tank, to total rupture. Now, here's why that's important. We feel that we'd like to know how much

the tank ruptured so that we can understand what caused this rupture. We can readily conceive of a burnthrough at the top of the tank because there are many wires that come together at the top of the tank and run out through this small conduit. This makes sense to us. Tests were just run here the other day that showed that not only might that small conduit burn through, but as much as a 2-inch hole in this particular case could burn through very rapidly.

Now, this ties into another series of tests, and that is how the panel came off the service module. The pulse required to take that panel off has been under study at the Langley Research Center with a very large crew of people working on this problem. The service module bay 4 has been mocked up in about one-half scale, and so far I think a series of about 15 tests has been run to attempt to pop the panel off in a realistic way, and this has all been scaled dynamically and structurally so that it does simulate the actual conditions. The first thing that was found out was that if you pulse a very rapid pulse in a local area, which simulated a very rapid, rather large rupture of the tank, it tore a hole in the panel. But if the pulse were just a little bit slower and gave sufficient time for the gas to spread throughout the whole bay and pressurized that panel fairly uniformly, it came off completely, and it came off at about the pressure it was designed for, which was between 20 and 25 psi. Now, there was some problem with these tests in the sense that the slow pulse which took the panel off pressurized some of the rest of the service module more than we think happened, because under one condition the pressure could have separated the command module. The command module was designed in such a way that if it had been pressurized at its heat shield area to 10 psi about, it would have come off. So we have been looking for a pulse that would take this panel off more abruptly and get it all off and this was achieved yesterday morning where we were running our second honeycomb reinforced panel. Prior to this test, the panels were single sheets simulating the tensile strength and the membrane properties of the actual panel. Some of the stiffness properties were injected the other day when we got our first scale honeycomb panels. They have now come off in total, not in one piece, but they've all come off with a sharp local pulse of the type we think occurred.

We've also been running extensive theoretical calculations at Langley to try to relate the shape of the pressure wave

and the total energy in it to what you might expect from various size ruptures in the tank. We're getting close to a match but we don't quite have it yet. Now if we've got a 2-inch hole in the tank, and we're not sure we did get it, just one test sample showed a hole about that size, that would about give the right size pulse. If it was something less, we might need an augmented pulse. There's one way you can get an extra kick into that pulse, and that is by burning of the Mylar insulation was right over the top of the tank. There's a test being run at Langley today to try to demonstrate that if the tank had burst, flooded the Mylar insulation with liquid oxygen, or a spray of liquid and gaseous oxygen, and had ignition sources present (which would almost certainly have been there with a burnthrough at the top of the tank) it would in fact, ignite and supplement the pressure pulse from the cold gas alone. Now this isn't quite pinned down yet. Obviously, I'm giving you some information in advance of conclusive results but I'm doing this so you'll understand what we're about. I guess the last thing I would say then is that the tests are all coming to a focus here this week. It's going to be very difficult to get the report in by next Monday. The Administrator is not putting me or the Board under pressure to get that report in but rather is urging us to take the time required to do a good job and we're going to do that. So that if additional time is required, we'll take it. I won't know for a few days yet. That's what I thought I would tell you, except to answer the questions.

QUERY: Would you just summarize for us the probable sequence of events that happened on Apollo 13 based on all the knowledge to date?

CORTRIGHT: Where do you want me to start?

QUERY: When the problems developed, what had happened that lead up to this problem on Apollo 13 ... based on the investigation?

CORTRIGHT: Well, I'll tell you part of it but I don't want to attempt to give you the whole sequence because there's some steps in it that we're still debating. In fact, I have to leave here before too long to go back and participate in a meeting with officials from the prime and subcontractor who built this tank to discuss some of the events that preceded the accident. But in a gross sense, it was believed to be something like this. The switches which failed at the Cape, we think, were not rated to the voltage levels to which they were subjected at the Cape. Normally

they would not have been opened under these voltages at the Cape, but they did so in the special detanking. This higher voltage failed the switches in a manner in which they could no longer function as protective thermostats. This in turn resulted in the heaters operating for a long period of time without interruption. The heater tube assembly reached temperatures which we suspect, locally, may have been as high as 1000° F. We have demonstrated that this seriously damages Teflon insulation. In flight, when the fan motor wires were energized for a normal stir of the oxygen, they short circuited at a point where the insulation had been damaged by this heater cycle. The short circuit was of such a nature that it created an electric arc which, in turn, ignited the Teflon insulation. The Teflon insulation burned towards the top of the tank. When it reached the top of the tank it ignited additional Teflon insulation around other wires which come together there, creating a local furnace which burned through the top of the tank in some manner. The high-pressure oxygen rushed out into bay 4, pressurized it with a sharp quick pulse, separated the panel, damaged the oxygen tank no. 1 system, resulted in the total loss of oxygen and power ultimately.

QUERY: What evidence is there that this happened before launch?
The switches were damaged before launch?

CORTRIGHT: The tests the other day showed — indicated that the switches can weld closed when they attempt to interrupt a current of the strength which was used at the Cape during a detanking procedure. Now the details of that, with regard to the actual rating of the switch, how it came to have that rating, I'm not prepared to discuss that today.

QUERY: How many times were the fans used before the explosion and why?

CORTRIGHT: I don't have that count, but they were used.

QUERY: More than once?

CORTRIGHT: Yes.

QUERY: Who authorized this special procedure for detanking?

CORTRIGHT: This was authorized through normal procedures at the Kennedy Space Center with checks with responsible individuals.

QUERY: Had they ever been used before?

CORTRIGHT: No.

QUERY: Do you know why they had trouble with these tanks?

CORTRIGHT: We suspect a loose portion of a filter assembly in the tank but I'd rather defer discussion of this aspect of it. I think I will defer at about this point because there are elements of it that are not yet clearly established and they will be in the final report to the Administrator which I'll make next week.

QUERY: Why was the failure of switches not discovered early in launch?

CORTRIGHT: The ground support equipment which monitored the tank did not readily or visibly display the heater operation and the operation of those two switches.

QUERY: And was no special step made to check those switches due to the fact that they had been taken above their rated voltages?

CORTRIGHT: No. I defer that question for the next time we get together.

QUERY: Well, what kind of voltage did your tests show? What voltage did the switches draw?

CORTRIGHT: 65 volts dc.

QUERY: When you said there was nothing on the ground support equipment, what do you mean, there was no indicator or gage or something, or what?

CORTRIGHT: I'm not sure I understand your question.

QUERY: You said there was nothing on the ground support equipment that would indicate the heater operation and the operation of the two switches?

CORTRIGHT: The voltage of the equipment is recorded but as far as I know, and this is one of the things we're checking into, there is no convenient way that would illustrate the cycling of those switches to the observer.

QUERY: Do you have a detanking procedure which was not normal, which had been described to us since is very strenuous, hard on the equipment, etc.?

CORTRIGHT: There were tests run in support of that operation to determine whether or not it was a safe procedure to follow. There was no mechanism hypothesized that could damage the tanks.

QUERY: No special tests were run after the procedure was completed to back check the two switches?

CORTRIGHT: I feel it's very important to be accurate in regards to this switch malfunction because it probably was the final thing that occurred during ground tests which caused the accident. I think it'd be seriously wrong on my part to speculate in any way.

QUERY: Cortright, you say that welding occurred at 65 volts dc?

CORTRIGHT: I'm not exactly sure of the exact number so I'd rather not answer that.

QUERY: Dr. Paine testified on May 19 before the Senate Appropriations Committee that modifications are being made. Is that true?

QUERY: What does that mean?

CORTRIGHT: It means that work is going ahead as planned.

QUERY: But no nominal gain made, is that right?

CORTRIGHT: The fix has not yet been authorized.

QUERY: As I understand it, this heater switch business is something that you became fairly sure of last week, is that correct?

CORTRIGHT: Yes.

QUERY: That would have been after Dr. Paine said that modifications are being made, it raises a question of will this necessitate further modifications?

CORTRIGHT: This switch, I believe, had already been taken out for subsequent flights prior to the accident, and the discovery of the switch problem merely helps us be certain we knew what happened. It doesn't change the approach to the fix.

QUERY: What about pinning the fault of the explosion on the detanking operation? Does this mean that whereas the detanking

in the past has been sort of thought to have been a one-of-a-kind failure and there may be some modifications coming out of it now? Further modifications?

CORTRIGHT: I don't believe that the normal detanking procedure will be changed as a result of what we learned. Certainly the special KSC detanking procedure will not be followed again.

QUERY: This sounds like not an equipment failure, but human failure in not using the equipment properly, is that right or not?

CORTRIGHT: There appears to have been a mismatch between the ground support equipment and the switches which were used on the spacecraft, and what we're trying to pin down now is how that occurred.

QUERY: You're saying that the people conducting the test felt that these switches could handle the current used in the test. Did they use too much current?

CORTRIGHT: It was too much for switches that were on board.

QUERY: Are you saying in essence that you think it means they know what kind of switches were on board?

CORTRIGHT: Yes. They didn't know that the switches would not handle that current.

QUERY: Had there been a change in switch specs somewhere along the line?

CORTRIGHT: I understand why you want the answers to all these questions, but I am not prepared to give much more than this today because I don't have all the answers yet. As I say, we're meeting at 3 o'clock, to attempt to pin some of these things down. If I attempt to answer any more questions about these events, I'll be changing the answers tomorrow...

QUERY: ... switches to be set, was this known?

CORTRIGHT: It was known to some.

QUERY: To the people operating the ground support equipment?

CORTRIGHT: No, I said that they -

QUERY: The people operating the ground support equipment.

CORTRIGHT: No, I said that they felt the switches were rated at the level to which they were using them.

QUERY: Has NASA called for or requested a change in switch specifications anywhere along the way here?

QUERY: What are the switches rated at? What were the switches that were in there rated at? We've got 65 ...

CORTRIGHT: We're double checking that, and we'll tell you when we know.

QUERY: You said that this thermostat switch had been taken off in future flights?

CORTRIGHT: I think so.

QUERY: Do you know why?

CORTRIGHT: Pardon?

QUERY: Do you know why that it was taken off?

CORTRIGHT: I'm not positive that I have all the information on it, but normally those switches are never used. They would normally be used in very unusual condition where the oxygen in the tank got down to a few percent of maximum during flight, and the tanks aren't used that way. But they were used that way during this detanking procedure.

QUERY: The switch removal then is not one of the steps that you ordered as part of the fire proofing procedure?

CORTRIGHT: No, sir.

QUERY: These switches, are they inside the tank, outside, or where?

CORTRIGHT: They are inside the tank, mounted on the inside of a heater tube, near the top.

QUERY: Then Apollo 13 would have been the last flight to the best of your knowledge at this point in time that would have had those switches in it?

CORTRIGHT: I'm going to ask Brian Duff to check that for me. I'm not certain. That's my recollection.

QUERY: We've got one question from Washington. Wait a second.

QUERY: ... and the mismatching of switches in GSE, etc., are you coming to the conclusion that perhaps there has been over a period of time ... a letdown in quality control and attention to detail that's got to be shaped up?

CORTRIGHT: We're not going to come to that conclusion today. We're trying to reach conclusions so that we can make recommendations to the Administrator next week. I guess that will have to be my answer for today. Let me say one other thing in answer to that question. I have not detected any letdown in quality assurance as set up for this program and as carried out. In fact, we have found that the quality assurance program is about the most rigorous we've ever seen and that it's carried out to the letter. That does not mean that the best systems can't let things slip through occasionally.

QUERY: You said that the ground support people didn't know that that switch couldn't take that current but that some people did know it. Were these some people that were at the Cape that were involved in the procedures?

CORTRIGHT: We're trying to determine today and this week who did and who didn't know and what information was exchanged among them.

QUERY: You certainly have given an overall impression at least that there was either a substandard switch involved or that some documentation along the way didn't get passed along, or that something in this area probably occurred. Is that what you're looking at, at least is that possibility you're looking at?

CORTRIGHT: I think it's clear that a mistake was made. That's what we're looking for.

QUERY: Does it look more like a hardware mistake or a documentation mistake?

CORTRIGHT: I'm not certain just what aspects have been ... most significant.

QUERY: Then why ...

CORTRIGHT: I'd rather not get into a discussion of this today, if you don't mind.

QUERY: Dr. Cortright, how did you come to suspect the switches? Was it because the detanking procedure was a deviation from the normal way of doing things, that an investigation of this type you would normally look into a thing like that?

CORTRIGHT: That's the first part of it. It was an abnormal thing. The tank failure was abnormal. You try to put two and two together. We did recognize immediately that if those switches had not operated that the heaters could have gotten quite hot, so we undertook with the Manned Spacecraft Center to conduct tests to determine how hot the heaters might have gotten. In the process of conducting those tests, the switches actually failed in the manner I described. It wasn't actually during the test of the switches themselves but they did weld themselves shut and therefore pinned down a key step in the whole process.

QUERY: Well, do you feel that the sequence was a failure? When the switches failed at Cape Kennedy and generated possibly 1000 degrees of temperature, this in effect did some baking of the insulation. Subsequently, use of the fans and the heaters continued to bake and on April 13 the insulation just gave way and arced. Is that what happened? After a continual exposure to this high heat?

CORTRIGHT: We expect that the insulation was in bad shape at launch and just why it took as many hours as it did to strike an arc we don't know, but there are mechanisms that you can speculate on. For example, there are wires that are relatively free. They are loops in the tank, and these loops no doubt do some moving around each time the fans come on and stir the fluid. They conceivably get moved back to a point where they had once been in contact with the heater and were damaged, and if at the time they moved back they were bare, partly bare because of the damage, it would strike an arc. That's one way it could happen. We may never know.

QUERY: Do you have a certain amount of sloshing in those tanks by just attitude changes? Do they slosh ... ?

CORTRIGHT: Well, sloshing is not the right description, but a gentle reactive motion.

QUERY: The loops — the wires could move within the tank in this kind of motion?

CORTRIGHT: Yes, but when the short circuits took place was immediately following turnon of the fans.

QUERY: When was it first discovered that more voltage was applied to the switches than should have been?

CORTRIGHT: Last Wednesday. We reported it to you last Thursday.

QUERY: Was that just a studying of documentation of test at the Cape? Is that right?

CORTRIGHT: That was by having the switches fail during the ground tests and attempting to understand why they failed.

QUERY: How did you become positive that the switches were failed at the time of launch? Is this hypothesis based on these tests or was there some documentation that you could go back to for the GSE to determine this?

CORTRIGHT: The records I've seen to date indicate that the rating of the switches was lower than the voltage supplied to them and that this makes it seem rational that since they failed in ground tests at the voltage used at the Cape, that they in turn had failed at the Cape. Now, some of the tests that are being run this week, and I'd like to make a strong point of this, are to validate in fact that these switches would normally fail at the applied voltages and that it wasn't simply an odd occurrence here in a test at MSC.

QUERY: That's the purpose of the voltage test for the flight model?

CORTRIGHT: Actually — excuse me, I want to answer that question. That isn't one of the main purposes of that test and I don't know what configuration those switches are in in that tank; they may, in fact, be wired closed. But there will be more switches tested here to get a little bit of statistical sample as to whether they would always weld closed.

QUERY: Would you run through in a very brief capsule summary, the tests that were conducted, in the sequence in which they were conducted and the place they were conducted leading up to this day and this week, this month? MSC switch failure found and pick up from there.

CORTRIGHT: I guess I won't try to do that because I don't have all those dates and sequences that sharply in my mind. The key test was here at MSC last Wednesday in which the switches failed.

QUERY: Is there any sensor ...

CORTRIGHT: No. The thermal switch itself is set to open at 80° F plus or minus 10°.

QUERY: Yeah ... thermal switches, is there any idea ... it's two dimensional.

CORTRIGHT: I'm not prepared to discuss the details of that. Now I can guarantee you that there will be thought given to need for such a measurement. I'm not sure if it's needed.

QUERY: Plus or minus 80 degrees - plus or minus how much you can handle ...

QUERY: How did you decide that the insulation was in bad shape or not? I would ...

CORTRIGHT: Just happened to have. (Laughter.)

CORTRIGHT: I intended to bring along and show the original condition so you could imagine that. This is a piece of wire that was baked for 1 hour at 752° F; the insulation is cracked and opened up at various positions on the wire. That represents 1 degree of insulation damage. Subsequent movement of shaking and thermal stresses might have caused pieces to flake off. Now at a little bit higher temperature, 860° F, you can see the insulation is largely gone. That was after 1/2 hour. Now we know that we were quite sure that some portions of the heater tube reached 1000°, probably most of it didn't but it could have been local damage perhaps as bad as this.

QUERY: You'd call that thing cooked, wouldn't you?

QUERY: Several hours, at the Cape at 1000° and this burned off in a half hour; how did he even get airborne?

CORTRIGHT: That's good question and I just don't know the answer to that question. We only have a few measurements in our tests so far that give temperatures on that heater. One of them went as high as I mentioned (1000° F) and it was

very close to the actual heater element. The temperature dropped off fairly rapidly away from that element, I've been led to believe. And therefore, the wires may not have approached these temperatures on most of their length. All we have established really is that the potential was there to destroy the insulation on the wires at least locally.

QUERY: How close is this fan wire adjacent ...

CORTRIGHT: The lower fan motor wires run through the heaters through a small conduit.

QUERY: What's the material of this conduit?

CORTRIGHT: Inconel. I think I'm going to have to limit you to about one more question. Then I have to get back to the meeting.

QUERY: Can you even ball-park roughly how this 65 degree — did you say the voltage it was supposed to be in the switches was two times as high, three times as high, four times as high?

CORTRIGHT: No. I'd rather not. I have an approximate number, but we're checking that today.

QUERY: Could you even just give us a rough thing like it was quite a bit higher?

CORTRIGHT: Was larger.

QUERY: Was it quite a bit larger?

CORTRIGHT: It was large enough, I think, to weld them.

QUERY: What was the material that ... checked?

CORTRIGHT: ... (Laughter.)

STATUS REPORTS OF THE APOLLO 13 REVIEW BOARD

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Status Report No. 1
April 21, 1970

The first meeting of the Apollo 13 Review Board was convened by Chairman Edgar M. Cortright at 8 p.m., c.s.t., April 21, at the Manned Spacecraft Center, Houston, Texas. The Board adjourned at 10 p.m. Present for the first meeting, in addition to the Chairman, were Board Members Neil Armstrong, John F. Clark, Milton Klein, W. R. Hedrick, and Charles W. Mathews. Cortright said the other Members of the Board, which was appointed by NASA Administrator Thomas O. Paine yesterday, intended to join the Board in Houston today. The Members unable to attend last night's preliminary meeting were Dr. H. M. Mark, Robert F. Allnutt, and Vincent L. Johnson.

The Board immediately set itself a work routine which will begin with a 7 a.m. breakfast and end at 9 p.m.

In addition to its own planning meetings and fact-finding sessions, Chairman Cortright allocated an important part of each day to coordinate reviews with the Manned Spacecraft Center's Apollo 13 Investigation Team. Cortright said the Board intended to rely heavily on the data-gathering and analytical capabilities of the Apollo Program Office Team, while at the same time insuring that the Review Board had within its own organization the competence and depth to make a completely independent assessment of any findings or recommendations of the MSC team or any other source.

In this regard, Cortright said the Review Board will wait until later this week when it has had a chance to hear a detailed briefing from the Apollo Program Office Team before it makes final decisions about recruiting additional support or advisory assistance. He said it was too early to know just where and what additional strength will be needed.

Status Report No. 2
April 22, 1970

The Apollo 13 Review Board held its first full day of meetings at the Manned Spacecraft Center today. The Board began the day by familiarizing itself with the status of the investigation of the accident currently underway by the engineers of the Manned Spacecraft Center and its contractors.

Following this the Board took its first detailed look at the suspect area of the liquid oxygen tanks in the service module. E. M. Cortright, Board Chairman, stated that this review included a study of the telemetry records and the anomalies which preceded the destructive event. A detailed discussion of possible causes of failure followed, and the Board members had the opportunity to carefully examine specimens of the type that failed.

Status Report No. 3
April 23, 1970

The Apollo 13 Review Board settled into a routine today, which Board Chairman Edgar M. Cortright expected would carry it at least through next week without a break.

The entire membership of the Board sat in as observers for an early-morning status briefing by Apollo Spacecraft Program engineers on the progress of all investigations and testing currently underway at NASA installations or contractor plants.

Immediately afterward, Cortright called the Board and its supporting experts into session to make the assignments of responsibility as the Board began to tackle in earnest its job of determining what happened to cripple the Apollo 13 service module, why it happened, and to recommend corrective action.

Board Member Neil Armstrong, astronaut, was asked to oversee the area of Mission Events. Mr. Frank Smith, Assistant Administrator, University Affairs, NASA Headquarters, was named chairman of a panel of supporting experts. Board Member John Clark, Director of the NASA Goddard Space Flight Center, was given responsibility for the area of manufacturing and test, and Mr. C. B. Schurmeier of the Jet Propulsion Laboratory was named chairman of the supporting panel. Board Member Vincent L. Johnson, NASA Headquarters, was given responsibility for the area of design, and Mr. S. C. Himmel, Assistant Director for Rockets and Vehicles, Lewis Research Center, will chair the supporting panel. A study of project management aspects pertinent to the Apollo 13 incident will be under the direction of Board Member Milton Klein, Manager of the AEC-NASA Space Nuclear Propulsion Office, and his supporting panel will be headed by Mr. Edward Kilgore of the NASA Langley Research Center. Cortright requested the responsible Board Members and their panel leaders to determine quickly what kind of additional help they will need to carry out their assignments and to submit their recommendations for his approval.

Another of the Board Members, Brigadier General Walter R. Hedrick, Jr., USAF, was given a special assignment to facilitate integration of the various panels' activities.

Dr. Hans Mark, a Member of the Review Board and Director of the NASA Ames Research Center, was given responsibility for special testing and analyses and for identifying consultants if needed.

Mr. Charles Mathews, NASA Headquarters, was asked to supervise liaison between the work of the Review Board and the investigations being carried on by the Apollo Program Office.

Board Member Robert Allnutt, a special assistant to the NASA Administrator, was put in charge of documenting the Board's plans and procedures, and planning the form of the Board's official report.

A fourth official observer was added to the Board today at the direction of NASA Administrator Thomas O. Paine. He is James E. Wilson, technical consultant to the House Committee on Science and Astronautics. Cortright said Wilson, like the other official observers, will sit in on all Board activities.

Status Report No. 4
April 24, 1970

Members of the Apollo 13 Review Board and a number of the Board's supporting experts will make a 1-day field trip to the North American Rockwell plant at Downey, California, tomorrow.

Board Chairman Edgar Cortright said the purpose of the trip will be to inspect available hardware with particular emphasis on the equipment in bay 4 of the service module; to inspect and review any tests which are being conducted as a result of the Apollo 13 flight; and to give the Board Members a complete history of the oxygen system which flew on the Apollo 13 spacecraft. North American Rockwell is the prime contractor for both the Apollo command and service modules.

Review Board Members, in addition to the Chairman, who will make the trip are: Dr. John Clark, Dr. Hans Mark, Mr. Vincent Johnson, Brigadier General Walter R. Hedrick, Jr. (USAF), Mr. Milton Klein, and Mr. Neil Armstrong.

Panel Chairmen making the trip will include: Mr. H. M. Schurmeier, Mr. Frank Smith, and Mr. S. C. Himmel. Mr. Charles Mathews, who is responsible for liaison between the Review Board and the Apollo Program, will make the trip, as will a number of other supporting specialists and staff members.

The Board plans to leave Houston via Air Force jet at 8 a.m. Sunday morning and return to Houston late the same day. The panel will be at the North American Rockwell plant approximately 7 hours.

Status Report No. 5
April 27, 1970

Apollo 13 Review Board panel chairman Harris M. Schurmeier will accompany Apollo project engineers to the plant of the Beech Aircraft Corporation in Boulder, Colorado, on Tuesday to witness the assembly of an Apollo service module oxygen tank.

Beech builds the tank as a subcontractor to North American Rockwell. Schurmeier said the primary purpose of his visit to Beech will be to follow in detail the normal assembly procedures practiced during the insertion of components inside the service module tank. Several Review Board specialists and Apollo project engineers will make the trip also. Schurmeier, of NASA's Jet Propulsion Laboratory, is chairman of a panel of specialists which is assisting the Review Board in the area of manufacturing and test procedures.

Other Board and panel members broke up into working groups today to continue their review of the available data concerning the destructive incident which made it necessary to abort Apollo 13's mission to the Moon.

Status Report No. 6
April 28, 1970

The Apollo 13 Review Board examined carefully processed photographs of the damaged service module today but found the pictures inconclusive.

"It is our opinion that the photographs, at their present stage of processing and analysis, do not establish the condition of the number two oxygen tank or even its presence," said Board Chairman Edgar M. Cortright.

The photographs were taken by the Apollo 13 astronauts after their command module had separated from the service module just before reentry. The pictures, from 70-millimeter still photographs and frames of 16-millimeter motion picture footage, show the interior of the service module's bay 4 which contained fuel cells and oxygen and hydrogen tanks. The Board had hoped that the photographs would help establish the condition of the number 2 oxygen tank, prime suspect in the Apollo 13 equipment failure. Efforts to bring out further detail in the photography with sophisticated enhancement techniques continues here at the Manned Spacecraft Center and elsewhere around the country. However, the products of this work will not be available to the Board until sometime next week. Members of the Board and Apollo Program engineers have said from the beginning that the most valuable clues to what happened in the service module will come from the telemetered data received from the spacecraft, rather than from photography.

Chairman Cortright said that the Board and the MSC team investigating the accident will make interim progress reports to NASA Deputy Administrator George Low on Friday morning at the Manned Spacecraft Center. In the meantime, study of data by the various investigative panels continues.

Status Report No. 7
April 29, 1970

The Management Panel of the Apollo 13 Review Board scheduled inspection trips to the North American Rockwell plant at Downey, California, today and to the Beech Aircraft Corp. plant at Boulder, Colorado, tomorrow.

Panel Chairman Edward Kilgore, of the NASA Langley Research Center, heads the Board's team of specialists. The Panel is charged with a study of project management aspects pertinent to the Apollo 13 failure.

Status Report No. 8
April 29, 1970

Dr. Charles D. Harrington, Chairman of the Aerospace Safety Advisory Panel, a statutory body created by Congress after the Apollo 1 fire, arrived today for 2 days of briefing by the Apollo 13 Review Board and Apollo Program engineers.

Dr. Harrington was accompanied by Mr. Carl Praktish, the Panel's executive secretary, and Mr. Emerson Harris, the Panel's deputy executive secretary. Dr. Harrington is an official observer of the Review Board. In addition, the Safety Panel has been asked by NASA Administrator Thomas O. Paine to review the procedures and findings of the Apollo 13 Board, and the Board is required to keep the Safety Panel informed of its work and progress.

Tonight (Wednesday) several members of the Review Board will experience, with fellow Board Member Neil Armstrong as a guide, what it was like in the Apollo 13 command module at the moment when the crisis was discovered. Armstrong said the command module training simulator at the Manned Spacecraft Center will be used to try to give the Board Members and some of the panelists a better appreciation of the failure from the crewmen's point of view.

"The Board Members will see what indications of the incident were available in the spacecraft and, particularly, how the positions of the various crew members would affect their ability to interpret what was taking place," Armstrong said.

"It is just one more way to reconstruct the incident," he added.

Status Report No. 9
April 30, 1970

Members of the Apollo 13 Review Board and its Panels spent most of today summarizing findings to date for an interim review of progress for NASA Deputy Administrator George Low. Low will get a 3-hour combined briefing from the Board and project officers.

Status Report No. 10
May 5, 1970

The Apollo 13 Review Board and the MSC Apollo 13 Investigation Team will brief the Aerospace Safety Advisory Panel all day tomorrow.

Dr. Charles Harrington, Chairman of the Panel, and seven panel and staff members will be given a complete review of the Apollo 13 failure and the progress of the investigations so far, and will meet with individual members of the Board. The Harrington Panel also will inspect the service module oxygen tank and associated equipment and will participate in a simulator demonstration. The Aerospace Safety Advisory Panel is a statutory body created by Congress after the Apollo 1 fire. NASA Administrator Thomas O. Paine has asked the Safety Panel to review all findings and procedures of the Review Board.

Members of the Board's Project Management Panel were at the Kennedy Space Center in Florida this week as part of a continuing study of all aspects of government and contractor management pertinent to the Apollo 13 failure. The Board worked through the past weekend and on Monday taking progress reports from its four Panels - Mission Events, Design, Manufacturing and Test, and Project Management. The Board has been conferring, too, with the Apollo Program Team to determine the scope and variety of tests to be conducted at NASA installations or at contractor plants to further pinpoint the cause of the Apollo 13 failure and, eventually, to validate proposed design changes.

Robert Wells, an electrical engineer from the NASA Langley Research Center, joined the Design Panel this week.

Status Report No. 11
May 7, 1970

The Apollo 13 Review Board will take its first break this weekend since it went to work on April 21. Chairman Edgar M. Cortright said he would adjourn the Board on Friday and not reconvene until Tuesday, May 12. Most of the Board and Panel Members are from out of town and have not had a chance to get home since the Board was convened.

After the Board reconvenes next Tuesday, Cortright plans to stay in session until the end of the month in an effort to deliver a finished report on the Apollo 13 failure to NASA Administrator Thomas O. Paine by June 1. The day-to-day work of the Board and its Panels continues to be a detailed review of all available information on the Apollo 13 accident, testing of principal hypotheses, and preliminary work on individual segments of the report.

Status Report No. 12
May 13, 1970

Apollo 13 Review Board Chairman Edgar Cortright will be in Los Angeles tomorrow on business for the Langley Research Center, where he is Director. Board member Vincent L. Johnson, Deputy Associate Administrator for Engineering in NASA's Office of Space Science and Applications, is acting chairman in Cortright's absence.

In the meantime, our Board Members and Panel Chairmen worked to have a final report ready for NASA Administrator Thomas O. Paine by June 1. Today was spent interviewing persons with special knowledge of the Apollo 13 mission or Apollo spacecraft systems and in refining draft sections of the Board's report.

Status Report No. 13
May 25, 1970

The Apollo 13 Review Board expects to make its final report on June 8 instead of June 1, Chairman Edgar M. Cortright said today.

The 1-week delay in the previously announced schedule is to allow time for completion of special tests currently under way at NASA Centers and contractor plants, Cortright said. The Chairman said he informed NASA Administrator Thomas O. Paine of the need for the delay this morning.

Cortright said that in view of the new schedule, the Board will recess Wednesday evening and reconvene the following Monday morning. He said he plans to deliver the final report to Paine and Deputy Administrator George Low in Washington on Monday, June 8.

Status Report No. 14
May 27, 1970

A special detanking procedure which was applied to the no. 2 oxygen tank of the Apollo 13 service module before launch "probably resulted in major damage to the wiring insulation in the tank," the Chairman of the Apollo 13 Review Board said today.

Chairman Edgar M. Cortright said the probability that significant damage occurred to the insulation during the detanking procedures developed during tests conducted at the Manned Spacecraft Center in Houston, Texas, over the last few days.

The detanking, a partial draining of the oxygen in the tank, occurred during preflight preparations on the pad at the Kennedy Space Center before the launch of Apollo 13.

Tests will continue over the next few days in an effort to substantiate the findings so far, Cortright said, and the Review Board will hear the results of this work when it reconvenes at the Manned Spacecraft Center on Monday, June 1.

In discussing the detanking tests, Cortright said it now appears that two thermal switches, designed to protect the heaters in the tank from overheating, may have failed. In such an event, other tests have shown that the heater tube in the tank could have reached temperatures of about 1000° F and that such temperatures would seriously damage the insulation around the heater wires, he said.

Cortright said such insulation damage could have resulted in the arcing short circuits which are believed to have initiated the combustion of insulation inside the tank during the flight. The burning, in turn, raised the pressure of the supercritical oxygen and caused the tank to rupture.

Another area of testing which the Board will hear about on Monday seeks to determine the manner in which the tank finally failed and what mechanism was needed to cause the outer panel of the service module to blow off.

Cortright said the Board continues to expect to deliver its final report to NASA Administrator Thomas O. Paine and Deputy Administrator George M. Low on Monday, June 8, 1970.

Status Report No. 15
June 5, 1970

Apollo 13 Review Board Chairman Edgar M. Cortright said today that he plans to send the final draft of the Board's report to the printer about the middle of next week and deliver the full report to Dr. Thomas O. Paine, NASA Administrator, in Washington on Monday, June 15, 1970.

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