

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 in 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.

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.