

Colonel BORMAN. No; in addition we were radiating also. I think you will get a full explanation from the program office.

Mr. DAVIS. I was told it was 115 alternating current and 28 volts direct current. Were your communications conducted on 28-volt direct current?

Colonel BORMAN. The power that goes to the communication system was direct current.

Mr. FAGET. The radio link is powered by the 115-volt alternating current.

Mr. DAVIS. What about the microphone that you thought had grounded out?

Mr. FAGET. That operates at a very low voltage direct current.

Mr. DAVIS. It was not 28 volts?

Mr. FAGET. No.

Mr. DAVIS. Didn't you testify that the one example of arcing that you knew about occurred on 28-volt direct current?

Mr. FAGET. The one example of arcing that we showed a picture of, that was 28-volt direct current power.

Mr. DAVIS. Would that be the same as your communication power?

Mr. FAGET. No; that was supplying power to the plus yaw thrusters in the service module.

Mr. GURNEY. Again on the same problem, I think we rushed over it a little too lightly.

What were these overall communication failures?

Colonel BORMAN. Primarily the inability of certain test elements to maintain communication with one another and with the spacecraft.

Mr. GURNEY. Is this the same system that will be used in the spacecraft in flight?

Colonel BORMAN. The main problem was with the ground communication system. The problem for this particular test centered in the ground communication system.

Mr. GURNEY. Were there problems in the communication system which the spacecraft would be dependent upon in space?

Colonel BORMAN. Not to my knowledge, for this test.

Mr. GURNEY. Why is the statement made that the overall communication system was unsatisfactory?

Colonel BORMAN. We should have stated that the overall ground communication system was what the Board found unsatisfactory.

Mr. GURNEY. Why is the Board recommending that a detailed design review be conducted on the entire spacecraft communications system?

Colonel BORMAN. Because the block I spacecraft communication system has gone through an evolution of change which resulted in different functions for various switches. It was a rather complex requirement for the crew to ascertain what communication mode that they were in.

I believe you will find that this requirement has been fulfilled in the block II design. I think you asked me to point this out. I think this has been fulfilled in the block II design, but in our recommendations and our findings we were constrained to report on what we investigated.

Mr. DAVIS. Were the communications between the astronauts and the ground control, or whatever you want to call it, conducted by what you call a land line or on radio frequency?

Colonel BORMAN. Both. During the test it was switched around considerably.

Mr. DAVIS. If I had known that, I wouldn't have asked you about the 28-volt direct current. You are using a redundancy of systems?

Colonel BORMAN. Yes, sir.

Mr. WYDLER. You are not implying there was any connection between the communications direct current efficiencies and the accident, are you?

Colonel BORMAN. No, sir. I pointed that out when I made the recommendation.

I think I have covered this slide. We note there are 209 pages added to the checkout procedure. Much of the material was the same. If you want to change two or three lines, you have to change the whole page. It is more convenient to do that because they are all machine typed. Although the quantity—the actual number of changes were not large, it resulted in a large change in the test procedures and the Board did not consider this desirable.

Next slide. We determined that neither the revision nor the differences contributed to the accident. The late issuance of the revision, however, prevented test personnel from becoming adequately familiar with the test procedure prior to its use.

Mr. FULTON. You mean the personnel was acting without becoming adequately familiar with the test procedure?

Colonel BORMAN. Yes, sir.

Next slide. Recommendations: (a) Test procedures and pilot's checklists that represent the actual command module configuration be published in final form and reviewed early enough to permit adequate preparation and participation of all test organization. (b) Timely distribution of test procedures and major changes be made a constraint to the beginning of any test.

I might point out this is one of the more difficult things to accomplish because we do have a dynamic program and it is very difficult to keep all the inputs from all the different organizations in the paper-work channel and get them out in a timely manner.

Mr. FUQUA. Colonel Borman, what do you think is a reasonable time that a pilot should be informed of these changes before the test?

Colonel BORMAN. Two days, in my opinion.

Mr. FUQUA. Maybe this should be spelled out in the recommendation.

Colonel BORMAN. I was not speaking as a Board member. Maybe I should switch the light on and off as you do. I was speaking as a pilot.

Mr. FULTON. We have seen pictures of this particular crew out in the open from time to time, studying these procedures. Were those procedures that they were studying up to date in every instance as time went on in preparation for this manned space flight? Were they current, so that the men were actually looking at current procedures and not getting a hash of old and new?

Colonel BORMAN. Yes, sir; the things we study are the things for the flight. The test procedures for the ground test you would like to have 2 days before to look over. You don't commit them to memory. The ones that they are studying and the ones you spend the most time on are the in-flight procedures. They were up to date and the crew was primarily responsible for keeping them up to date.

Mr. FULTON. There was not a mixture of old and new, you are sure everything was kept up to date on those revisions?

Colonel BORMAN. As far as I know. I can't speak for the 204 crew, but I can check with the backup crew and find out how they went.

Mr. RUMSFELD. Who is responsible for preparing these procedures and checklists?

Colonel BORMAN. We have a crew that is responsible in conjunction with the contractor.

Mr. RUMSFELD. Is it a NASA group in conjunction with the contractor?

Colonel BORMAN. Yes, sir.

Mr. RUMSFELD. Would these recommendations be for those individuals in that particular group?

Colonel BORMAN. I may have misunderstood. The test flight procedures are the responsibility of the contractor and NASA test organization at the Cape.

Mr. RUMSFELD. It is dual responsibility?

Colonel BORMAN. Yes, sir.

Mr. RUMSFELD. Thank you.

Mr. KARTH. Who determines what a major change is and when it constitutes a major change?

Colonel BORMAN. In my opinion 209 pages is a major change.

Mr. KARTH. How about 109?

Colonel BORMAN. This is a qualitative opinion and the Board was of the opinion for this particular test this was a major change. If I were running a test, I would like to have the test procedure as it was going to be run, with the exception of perhaps minor changes, at least 2 days before the test.

Mr. KARTH. The only purpose of my question is: if you have people disagreeing on what major changes are, you may find the test is taking place a long time before the changes have been evaluated.

Colonel BORMAN. Yes, sir. While the recommendation may seem trivial it is one of the more difficult ones to implement.

Next side. Eight. Finding: The fire in Command Module 012 was subsequently simulated closely by a test fire in a full-scale mockup.

Mr. FULTON. What was the result? You tried to do it in the same way so you would get the same result. Tell us how much of a result you got.

Colonel BORMAN. I defer to Dr. Van Dolah.

Mr. FULTON. We could say, the simulation.

Dr. VAN DOLAH. It is a degree of judgment. The Raschel net has been the most probable area of the ignition.

Mr. FULTON. That was nylon.

Dr. VAN DOLAH. And the pressure trace which is our best indication of an effective simulation very closely simulated that we think occurred in 012. It was equipped with a blowout valve located in the same general vicinity as the break in Command Module 012 and the total rise in pressure and fall, decay of pressure came close—within seconds—of the pressure trace in spacecraft 5.

Mr. FULTON. Are you saying the spacecraft proved to you beyond a reasonable doubt that is the way the fire occurred? Can you give us an estimate of how the simulation affected your judgment on the cause of the original fire?

Dr. VAN DOLAH. We had been talking about the fire origin for several weeks prior to the simulation test.

This test was run last Tuesday.

Mr. FULTON. How do you feel about the original fire?

Dr. VAN DOLAH. It merely confirms our original judgment.

Mr. FULTON. It confirms it beyond a reasonable doubt or with some doubt?

Dr. VAN DOLAH. I suppose there will always be some doubt.

Colonel BORMAN. Next slide. Determination: Full-scale mockup fire tests can be used to give a realistic appraisal of fire risks in flight-configured spacecraft.

As Dr. Thompson pointed out, this is a particular new tool.

Next slide. Here we come to a recommendation poorly worded. We really don't mean we want to burn a spacecraft in flight configuration. We are talking about a mockup in simulated flight configuration to be used to determine the risk of fire.

Mr. GURNEY. In these fire tests of a full-scale mockup, has NASA done any other than the one which they think started this particular fire?

Colonel BORMAN. I think all the tests that have been done on full-scale mockups have been in support of the Board's activities. I would have to say that most of the tests have been done in attempting to determine the cause, the ignition source, and the spread of this particular accident, this particular fire.

Mr. GURNEY. This may not be a fair question to you. I judge from the recommendation, or the finding, whichever it was, that there would be other tests simulating other possible sources of ignition.

Dr. FAGET. The program office people have made, I believe, two other tests in simulated mockups using substitute material. I don't believe the Board should be asked to evaluate those tests because I think the program officers are better able to do that for you.

Colonel BORMAN. They didn't do the tests until after the fire. They were done in attempting to gain experience regarding this particular fire.

What we hope is that when we get a reconfigured spacecraft with the Beta cloth and Teflon, we can place ignition sources in different areas and see whether it will burn.

Next slide.

Mr. FULTON. Should we hold up all further manned space flight tests until we retool the whole capsule and make sure that there are no flammable materials in the capsule? For example, should they all be fiberglass or materials of that nature that might melt? When we were down in Houston and saw those tests run, I didn't need any particular shocker to tell me that when we saw static charges run along a wire like a Fourth of July sparkler in various oxygen atmosphere pressures, that particular wire or cable can't be used. Should we have a complete overhaul and a complete new look? Or should we just reduce the flammable qualities? After seeing some of the equipment at Houston with the chairman and some of the others, it certainly told me that a big look should be taken.

What do you think?

Colonel BORMAN. Dr. Thompson.

Dr. THOMPSON. The matter of material selection is a matter that has received the greatest attention and the panel 8 report covers a

great deal of information that has been obtained from that. There is certainly a great deal of promise in substituting materials within a spacecraft. I doubt that this is a major holdup. I think the advancement in materials is such that the revision of the materials or the replacement and substitution of materials with some improvement in rearrangement offers a very drastic reduction in the fire risk by using the materials that are now available as shown by tests that now can be made.

The advantage that we have now over the situation that prevailed just prior to this accident is that this accident has stimulated this method of evaluating a fire risk and prior to that a fire risk was being evaluated by lab samples, the burning rate of small pieces of materials. This simulation technique has shown that such tests do not take into account the geometry, the way the materials are laid out, the way they are woven and laid out, and therefore can be misleading. This simulation device has been validated in our opinion, and in the opinion of the program office, as a very useful tool for not only establishing the points that are of primary interest to the Board, but as a tool to qualify the vehicle that they will ultimately come up with with materials arranged in such a way that the fire risk will be greatly reduced. We expect the program office to use this as a means of qualifying the selection and arrangement of materials in a future flight.

Mr. FULTON. The testing brings up the question of whether our tremendous commercial airplanes with their oxygen drop-down equipment are safe, if there is such a risk of fire? Are these airplanes safe? Are we going to have something like this happen to 85 passengers?

Dr. THOMPSON. I don't believe there is any absolute safety in anything. It is a matter of relative risk that we are dealing with.

Mr. FULTON. Nobody has done this in regard to airplanes, have they?

Dr. THOMPSON. As far as I know, this type of test is a new development, and I don't know who else would use it.

Mr. WAGGONER. I would be willing to try if it becomes necessary.

Mr. FULTON. We must see the applications of these tests to other fields. We must have an open mind and not proceed with the case in which we don't recognize a risk exists. I don't look at this as a failure of NASA, I look at this as a chance for new progress.

Colonel BORMAN. Shall I go on?

Mr. TEAGUE. Yes.

Colonel BORMAN. Nine. Finding.

The command module environmental control system design provides a pure oxygen atmosphere.

Determination:

This atmosphere presents severe fire hazards if the amount and location of combustibles in the command module are not restricted and controlled.

I think that it is important that we note here, too, it is not a fire hazard in itself, only if the amounts of combustibles are not controlled and restricted.

Recommendations:

(a) The fire safety of the reconfigured command module be established by full-scale mockup tests.

(b) Studies of the use of a diluent gas be continued with particular

reference to assessing the problems of gas detection and control and the risk of additional operations that would be required in the use of a two-gas atmosphere.

Mr. WYDLER. This is the recommendation of the Board that bothers me the most.

Colonel BORMAN. Which one?

Mr. WYDLER. This whole of finding No. 9. As I read this, but maybe I read it incorrectly, I interpret this as more or less a permissive statement by the Board to go right ahead with the oxygen system that they are using. Is it intended as that?

Colonel BORMAN. Sir, I think I would have to say that the Board feels that if the flammables and the combustibles within the spacecraft are controlled and restricted, and the new configuration is proven by a full-scale mockup test, they see no reason to change it.

Mr. WYDLER. It creates problems. One of the factors that we can control is the pure oxygen atmosphere itself.

Colonel BORMAN. I don't agree with you at all. If I can put on my other hat briefly, I would much rather fly in a spacecraft with a complete pure oxygen atmosphere that has properly tested—had the materials restricted and controlled and has been proven by a full-scale mockup, than I would attempt to modify the present Apollo design to a two-gas system.

Mr. WYDLER. Are you aware NASA is going to go to a two-gas system in their Apollo program?

Colonel BORMAN. I said in the present command model. I don't oppose it for flights in excess of 30 days.

Mr. WYDLER. What are the advantages of the pure oxygen?

Colonel BORMAN. They have been listed many times. Again I am speaking not as a Board member. One of the advantages I like about a single gas system in the present Apollo spacecraft is that it eliminates the requirement to depressurize the cabin as soon as you get in orbit. If you use a two-gas system on the ground and a one-gas system in orbit you have a requirement to purge the system. I don't like to take a new spacecraft immediately after it is inserted in orbit and expose it to a vacuum. I see no reason to change it provided we prove the reconfigured spacecraft does not present a fire hazard.

Mr. DAVIS. Do you have charts prepared that show ignition temperature and show burning rates?

Colonel BORMAN. Yes, sir; we have voluminous data on this.

Mr. DAVIS. It is based on the fact you feel a spacecraft could be constructed that would be reasonably fireproof?

Colonel BORMAN. I flew one for 14 days. The command module designed for lunar mission does not require more than 14 days' duration.

Mr. DAVIS. I will buy that.

Mr. WYDLER. Colonel, you stated before in your testimony, however, that you had learned something here today. You had learned that there is no such thing as a material that is not combustible. It is a question of degree.

Colonel BORMAN. I didn't state that. It must have been someone else. I said there was no such thing as fireproof, only fire resistant.

Mr. WYDLER. That is right. You know any material will burn.

Colonel BORMAN. I don't think Beta cloth will.

Dr. VAN DOLAH. In oxygen it won't.

Colonel BORMAN. Titanium will react with nitrogen so you see there are gases that are normally inert but that will react with certain materials in a violent manner.

Mr. DAVIS. Your basic inert gases are neon, freon, and one other. They won't burn.

Colonel BORMAN. I wouldn't know.

Mr. TEAGUE. Do you think your feeling about oxygen is shared by most of the astronauts?

Colonel BORMAN. Yes.

Mr. TEAGUE. I was told by Colonel Glenn that he felt that way.

Colonel BORMAN. I got home Friday for the first time in a while, and I ran a canvass and I think most of the people feel that way.

New slide. Ten.

Finding:

Deficiencies existed in command module design, workmanship, and quality control, such as:

(a) Components of the environmental control system installed in command module 012 had a history of many removals and of technical difficulties including regulator failures, line failures and environmental control unit failures. The design and installation features of the environmental control unit makes removal or repair difficult.

(b) Coolant leakage at solder joints has been a chronic problem.

(c) The coolant is both corrosive and combustible.

It is difficult to ignite but it will burn if heated to a high enough temperature.

(d) Deficiencies in design, manufacture, installation, rework, and quality control existed in the electrical wiring.

(e) No vibration test was made of a complete flight-configured spacecraft.

(f) Spacecraft design and operating procedures currently require the disconnecting of electrical connections while powered.

(g) No design features for fire protection were incorporated.

Mr. HECHLER. Mr. Chairman?

Mr. TEAGUE. Mr. Hechler.

Mr. HECHLER. Perhaps either you or Mr. Webb might care to comment on this question.

A lot of people have raised the point as to whether or not all of these things mentioned under No. 10 could better have been handled by the previous contractor, McDonnell rather than North American, and I just wondered if perhaps Mr. Webb would care to comment on this question.

Mr. WEBB. Mr. Hechler, I would be very happy to make a comment. When we were determining the method by which the Apollo system would be produced, at the beginning of the work, we examined with considerable care the question of how we should make the procurement. Now, we did in fact go out for a competitive procurement and the previous contractor, McDonnell Aircraft Co., who made Mercury and Gemini, was evaluated in that procurement. The present contractor, North American Aviation was selected as a result of this procurement action with a Source Evaluation Board that had a very great deal of help and had done its work carefully.

Dr. Gilruth was responsible for the Source Evaluation Board; Dr. Dryden, Dr. Seamans and I were unanimous in the selection of the

contractor. I think it is fair to say that the Apollo system is very much more complex than anything we have had.

Some people say from 10 to 20 times more complex. I think it is difficult to speculate that a contractor who had a piece of equipment to fly in near earth orbit and could take a good deal of the plumbing out of the spacecraft and put it in an adaptor section that would never have to reenter the earth could have done a better job. His task must be compared with the Apollo which must reenter the earth at very much higher energy dissipation rates with all of the other equipment intact inside the capsule. I think there is no evidence to support those statements today. The fact is that the people who are looking at the equipment at the cape now and making what I regard in many cases as irresponsible criticisms of it are looking at equipment that was designed not only to fly with three men in the cockpit. It also carries all the other equipment necessary to replace the three men so that we can test the Saturn V booster by sending this equipment out at a high altitude and driving it out in the earth's air so we test the heat shield. This is a difficult operation. A great deal of the equipment is put in by what some member of the committee called this afternoon, "handwork"—it doesn't look like a production module of something where you are going to make some 10,000 items. The test results have indicated that the equipment was ready to do its job. I think that all of us are very anxious to have complete confidence in this equipment when we have to make the decision to push the button and let these rockets fly will have again gone over this whole matter with the very greatest of care.

Second, I would like to point out that as we have to learn to develop equipment where there was no design but where the contractor and NASA had to go through the learning process. We had evolved a Block II design which takes into account many things that are criticized by this Board, in fact most of them that are important. I think you could consider Gemini made by McDonnell as a Block II Mercury made by the same company. We are going through a developmental problem on a very much larger and more complex and difficult system. I wouldn't want to leave you with the impression that I or anyone in the position of responsibility at NASA are satisfied with the work that we have done in NASA through our contracts with McDonnell or North American or the others. Every Gemini flight that we flew, as successful as they were, involved difficulties and troubles. I may say we had a good deal of very deep concern in the emergency recovery of those who made the first linkup and had to come down 500 miles off Japan because of a thruster that was not in good shape. So I would say that you not go back to 1961 if you expect to get ahead of the Russians or get near to them. The work of this Board is pointing to every item that every contractor and subcontractor and every responsible official, technical and administrative official in NASA must consider with the greatest of care. We have a strong determination to do all that is necessary to make things better than they have been. I think we will get that response from all of our contractors.

Mr. TEAGUE. We have this Board before us tonight. We have got Mr. Webb and Dr. Seamans coming back. I like Mr. Webb. He has a wonderful reputation but it is not for short answers. The chairman would like to be as flexible as possible. We have this very important group of men here for about another hour. Let us make our questions to them.

Mr. RUMSFELD. With respect to finding No. 10, particularly A and D, let me ask whether everything in the report is unanimous by your Board. Did the Board make a determination as to whether these findings were the result of poor performance by the contractor NASA or whether it was basic management shortcomings that were the actual causative agents.

Would you go beyond these specific findings as to what permitted those findings to be the case?

Colonel BORMAN. You have to say that there was a problem in the wire runs and in the wire design, manufacture, and installation on the Block I vehicles. The wire bundles were not constructed using three dimensional jigs. The wire was sometimes subjected to insulation stress. Some of the runs were not properly engineered and designed. The environmental control unit had development problems. We had many cases of problems and design difficulties. We removed and re-designed a regulator in spacecraft 012 while it was at the cape.

I think that these are problems that are inherent in most development programs. We are really talking about two systems, the electrical distribution system and the ECU. The electrical distribution leads to the black boxes, the equipment that is required to guide and control the spacecraft, and we found no evidence of problems within the black boxes. But we did see reasons to criticize and ask for improvements in the design, installation and so on of the wire. We asked for a look at the environmental control unit. There is no reason to believe it was a contributor to the initiation of the fire. It had some insulation that contributed to the severity of the fire.

Mr. RUMSFELD. I wonder if for the benefit of the subcommittee it might be useful if a request was made, separately, of NASA and the Review Board with respect to pages D-1311 of D-1313 of the appendix which I now have and have read.

Colonel BORMAN. I wouldn't want to challenge you if you read the entire appendix.

Mr. RUMSFELD. I said I read those pages—this portion. To have the Board submit to the committee a statement with respect to each one of these findings and determinations numbering 1 through 14, on those 4 pages, some of which led to recommendations in the basic report, indicating who had the responsibility with respect to the finding as made. I know this preliminary thing mentioned some of it, but first trying to pinpoint the responsibility and second, trying to pinpoint who the Board is making the recommendation to, who the Board thinks should in fact undertake to fulfill the recommendation.

Colonel BORMAN. I think 10 does not jibe with this one. You are on a different subject.

Mr. RUMSFELD. No. Somewhat different, but the communications question is in both places. Some result in recommendations that you are now reading.

Colonel BORMAN. I understand.

Mr. RUMSFELD. My request runs to just these three pages.

Mr. TEAGUE. Might the Chair suggest that in our executive session we list the things that we would like further things on and ask the Board to submit it to us.

Mr. RUMSFELD. I am convinced I would like to see that. It might

give us some clue as to what other information we want and what other witnesses it might be appropriate to call.

Mr. TEAGUE. Dr. Thompson, would you care to comment on the questions asked by Mr. Rumsfeld?

Dr. THOMPSON. The Board is reporting to the Administrator.

Mr. RUMSFELD. You are reporting to the congressional committee right now.

Mr. TEAGUE. I am sure they will submit anything we request of them. They have certainly been cooperative in every way, form, and fashion.

Mr. SEAMANS. Dr. Thompson is answering the question you asked. To whom are these recommendations being addressed?

Mr. RUMSFELD. You mean that the recommendations are all going to NASA? The Board did not think in terms of a specific part or office of NASA or of a contractor as to who should undertake the recommendation? Is that your point?

Dr. THOMPSON. We were charged to report to the Administrator.

Mr. RUMSFELD. Then the first half of the request could be revised.

Mr. WYDLER. Would you yield to me?

Mr. RUMSFELD. Yes.

Mr. WYDLER. Take item E, "No vibration test was made of a flight configured spacecraft."

Colonel BORMAN. This was an engineering judgment. The program office was of the opinion that a flight test of two manned vehicles was a sufficient vibration test. With block II there will not be an unmanned flight and the Board feels there should be a flight configuration test.

Mr. WYDLER. Who should have ordered that?

Colonel BORMAN. The Board if it thinks it is required.

Mr. RUMSFELD. The Board should submit information as to who was responsible on pages 1311 to D-1313. By whom was it "not considered" for example?

(Information requested is as follows:)

The organizational elements having primary and secondary responsibilities are identified after each Finding. The term primary responsibility means documented functional responsibility for the efforts involved in either the generation, review or approval of the subject matter treated in the Finding. The term secondary responsibility means an operational or developmental participation which, as a normal function, would require an awareness or surveillance of the subject matter treated in the Finding.

At Manned Spacecraft Center the organizational responsibilities have been defined to the directorate level within the Manned Spacecraft Center. The responsibilities fall into three groups:

1. Generation of procedures.
2. Review or approval of procedures or design.
3. Design of spacecraft or ground systems.

Manned Spacecraft Center, as an organization, had the responsibility for one or more of the three groups only in Findings 1-5 and 7.

At Kennedy Space Center, the organizational responsibilities have been defined to an Office or Division Level. The detailed delineation of areas of responsibility at KSC, it is understood, will be furnished by the Associate Administrator, OMSF. Therefore, to avoid unnecessary duplication, the Offices and Divisions have only been identified as having either primary or secondary responsibility.

At North American Aviation Florida Facility, the organizational responsibilities have been defined to the Department or Office level.

Sincerely yours,

FLOYD L. THOMPSON,
Chairman, Apollo 204 Review Board.

Enclosure.

ENCLOSURE 1

FINDING NO. 1

The applicable test documents and flight crew procedures for the AS-204 Space Vehicle Plugs Out Integrated Test did not include safety considerations, emergency procedures or emergency equipment requirements relative to the possibility of an internal spacecraft fire during the operation.

Manned spacecraft center

1. Apollo Spacecraft Program Office : Review.
2. Flight Crew Operations Directorate : Review.

*Kennedy Space Center**Primary Responsibility:*

1. The Safety Office of the Directorate of Installation Support (DSIS).
2. The Flight Systems Division of the Directorate of Spacecraft Operations (SCO).

Secondary Responsibility:

1. Test and Operations Office of the Directorate of Launch Operations (DLO).
2. SCO Test and Management Office.

*North American Aviation Florida Facility (NAAFF)**Primary Responsibility:*

1. NAAFF Command and Service Module (CSM) Safety Office.
2. NAAFF Spacecraft Engineering Department.

Secondary Responsibility:

NAAFF Spacecraft Operations Department.

FINDING NO. 2

There are no documented safety instructions or emergency procedures in existence which are applicable to the possibility of a serious internal spacecraft fire.

Manned spacecraft center

1. Flight Crew Operations Directorate : Generation (flight crew procedures only).
2. Apollo Spacecraft Program Office : Review/Approval.

*Kennedy Space Center**Primary Responsibility:*

1. DIS Safety Office.
2. SCO Flight Systems Division.

Secondary Responsibility:

1. DLO Test Operations Office.
2. SCO Test and Management Office.

*North American Aviation Florida Facility**Primary Responsibility:*

1. NAAFF Apollo CSM Safety Office.
2. NAAFF Engineering Office.

Secondary Responsibility:

NAAFF Operations Office.

FINDING NO. 3

The propagation rate of the fire involved in the AS-204 accident was extremely rapid (Reference report by Panel 5). Removal of the three spacecraft hatches to effect emergency egress from either the inside or outside involved a minimum of 40 and 70 seconds respectively under ideal conditions.

Manned Spacecraft Center

1. Apollo Spacecraft Program Office : Determined the acceptability of the spacecraft hatch design.
2. Engineering and Development Directorate : Determined the acceptability of the spacecraft hatch design.
3. Flight Crew Operations Directorate : Determined the acceptability of the spacecraft hatch design.
4. Flight Operations Directorate : Determined the acceptability of the spacecraft hatch design.

Kennedy Space Center

None.

FINDING NO. 4

Procedures for unaided egress from the spacecraft were documented and available. The AS-204 flight crew had participated in a total of eight egress exercises employing those procedures.

Manned Spacecraft Center

1. Flight Crew Operations Directorate: Generation.
2. Flight Operations Directorate: Approval.

*Kennedy Space Center**Primary Responsibility:*

The Emergency Egress Working Group (EEWG) of the Apollo Launch Operations Committee (ALOC).

The EEWG is comprised of appropriate disciplines from NASA, AFETR, and NAAFF personnel. Chairman of both the EEWG and the ALOC is the Director of Launch Operations, KSC.

FINDING NO. 5

The Apollo Flight Crew Hazardous Egress Procedures Manual contains procedures relative to unaided, aided and incapacitated flight crew egress. By scope and definition, this document is concerned only with evacuation of the flight crew from the spacecraft and the pad under hazardous conditions occurring primarily external to the spacecraft during a launch operation.

Manned Spacecraft Center

Flight Crew Operations Directorate: Generation.

*Kennedy Space Center**Primary Responsibility:*

Same as for Finding No. 4.

FINDING NO. 6

The spacecraft pad work team on duty at the time of the accident had not been given emergency training drills for combating fires in or around the spacecraft or for emergency crew egress. They were trained and equipped only for a normal hatch removal operation.

Manned Spacecraft Center

None.

*Kennedy Spacecraft Center**Primary Responsibility:*

1. DIS Safety Office.
2. DLO Test Operations Office.
3. SCO Test and Management Office.

*North American Aviation Florida Facility**Primary Responsibility:*

1. Apollo CSM Safety Office.
2. Spacecraft Operations Department.
3. Technician Support Department.

FINDING NO. 7

There was no equipment on board the spacecraft designed to detect or extinguish a cabin fire.

Manned Spacecraft Center

1. Engineering and Development Directorate: Determined the acceptability of the design.
2. Flight Crew Operations Directorate: Determined the acceptability of the design.
3. Flight Operations Directorate: Determined the acceptability of the design.

4. Apollo Spacecraft Program Office: Determined the acceptability of the design.

Kennedy Space Center

None.

FINDING NO. 8

Frequent interruptions and failures had been experienced in the overall communications system during the operations preceding the accident. At the time the accident occurred, the status of the system was still under assessment.

Manned Spacecraft Center

Apollo Program Office: Review.

Kennedy Space Center

Primary Responsibility:

1. DIS Safety Office.
2. DLO Test Operations Office.
3. SCO Test and Management Office.

North American Aviation Florida Facility

Primary Responsibility:

1. Apollo CSM Safety Office.
2. Operations Office.

North American Aviation Downey

Spacecraft Design Engineering.

Air Force Eastern Test Range

Range Safety Division.

FINDING NO. 9

Emergency equipment provided at the spacecraft work levels consisted of portable CO₂ fire extinguishers, Rocket Propellant Fuel Handler's Gas Masks and 1½-inch diameter fire hoses.

Manned Spacecraft Center

None.

Kennedy Space Center

Primary Responsibility:

1. Safety Office of the Directorate of Installation Support (DIS).
2. Test and Operations Office of the Directorate of Launch Operations (DLO).
3. Test and Management Office of the Directorate of Spacecraft Operations (SCO).

North American Aviation Florida Facility

1. Apollo CSM Safety Office
2. Operations Office

Air Force Eastern Test Range

Range Safety Division.

FINDING NO. 10

There are steps and doorways on the Launch Complex 34 Apollo Access Arm and in the environmental enclosure (White Room) which constitute safety hazards, particularly under emergency conditions.

Manned Spacecraft Center

Apollo Spacecraft Program Office: Review.

Kennedy Space Center

Primary Responsibility:

1. Emergency Egress Working Group.
2. DIS Safety Office.
3. DLO Test Operations Office.
4. SCO Test and Management Office.

North American Aviation Florida Facility

1. Apollo CSM Safety Office.
2. Operations Office.

Air Force Eastern Test Range

Range Safety Division

FINDING NO. 11

During the preparation of S/C test procedures at KSC, safety considerations for hazardous operations and documentation of applicable emergency procedures are limited in most cases to routine safety reference notations and emergency power-down instructions.

Manned Spacecraft Center

None.

*Kennedy Space Center**Primary Responsibility:*

1. DIS Safety Office.
2. SCO Test and Management Office.

North American Aviation Florida Facility

1. Spacecraft Engineering and Operations Departments.
2. Apollo CSM Safety Office.

FINDING NO. 12

Under the existing method of test procedure processing at KSC, the cognizant Safety Offices review only those procedures which are noted in the OCP outline as involving hazards. Official approval by KSC and AFETR Safety is accomplished after the procedure is published and released.

Manned Spacecraft Center

None.

*Kennedy Space Center**Primary Responsibility:*

DIS Safety Office.

FINDING NO. 13

Criteria for defining hazardous test operations are not complete.

Manned Spacecraft Center

None.

*Kennedy Spacecraft Center**Primary Responsibility:*

1. DIS Safety Office.
2. Directorate of Spacecraft Operations.

North American Aviation Florida Facility

Spacecraft Management Office.

FINDING NO. 14

Requirements for the review and concurrence of KSC S/C test procedures by MSC are not well defined.

Manned Spacecraft Center

Apollo Program Office.

*Kennedy Space Center**Primary Responsibility:*

Apollo Program Office.

Mr. WAGGONER. Did the Mercury program manager ask for and achieve a flight-configured spacecraft flight vibration test before an actual test?

Colonel BORMAN. We did on Gemini. I will have to defer to someone else on Mercury.

Max, did you vibrate Mercury?

Dr. FAGET. Yes.

Mr. WAGGONNER. Was it done in Gemini?

Colonel BORMAN. The only manned flight vehicle that was vibrated was No. 3, the first manned flight vehicle.

Mr. RYAN. May I refer to, in finding No. 10, deficiencies in design?

Colonel BORMAN. Yes, sir.

Mr. RYAN. Who was responsible for the design?

Colonel BORMAN. This was a joint responsibility. Certainly the contractor is responsible for providing an efficient design. NASA has a responsibility for approving that design.

Mr. RYAN. It is a function of procurement.

Colonel BORMAN. That is one of the aspects.

Mr. RYAN. Deficiencies in manufacture, installation, inspection, in quality control—who was responsible?

Colonel BORMAN. Both the contractor and NASA.

Mr. WEBB. May I give a brief answer?

Mr. TEAGUE. Yes.

Mr. WEBB. In the transition from Mercury to Apollo, we decided not to build in Government labs the competence to build detailed design. Instead, we gave the full information to the contractor expecting them to do as much as possible and to try to develop a system where the maximum amount would be done in industrial teams while we kept enough in-house competence to make sure the work was done. There is a shared responsibility but there was a shift between Mercury, Gemini, and Apollo in this regard.

Mr. RYAN. As a result of this shift, we have Finding 10D.

Mr. WEBB. And you have Block II coming along that incorporates a great many of the things that represents the same transition you have from Mercury to Gemini.

It is as if you started out to build another Rayburn Building about three times the size of this and 10 years from now.

Mr. RYAN. It was never intended to fly.

In what kind of atmosphere, I don't know. In any event, should not NASA have inspected and supervised this industry team to a greater extent?

Mr. WEBB. I think this will be explored in considerable detail as you have the contractor tomorrow and have us later. I can't answer that in complete brevity.

Mr. TEAGUE. Direct your questions to the Board.

Mr. RYAN. I directed my question to the Colonel, and Mr. Webb felt he had to supply the answer.

Colonel BORMAN. I think we both gave the same answer.

Mr. GURNEY. Let us go into this a little more. What deficiencies do you mean in quality control? Let us talk about the electrical wiring.

Colonel BORMAN. Improper installation, improper runs; we found cases where wires were supposed to be routed in particular channels and they were not installed in the particular channels. We had cases where the wire bundles were so located that it made removing items behind them extremely difficult.

This is what we mean by poor design of the wire runs.

Mr. GURNEY. My question is directed toward quality control. That, I suppose, is not a matter of manufacture. It is a process of inspection.

Somebody is responsible for seeing that you get quality. What were the deficiencies in quality control?

Colonel BORMAN. I think the problem enumerated in the design led to deficiencies in the electrical distribution system.

Mr. GURNEY. Is that supervised by the manufacturer or NASA?

Colonel BORMAN. Both ways.

Mr. GURNEY. How? Is there a man sitting there to see that it is done right?

Colonel BORMAN. Mr. White is responsible. He can answer it better than I.

Mr. WHITE. The basic responsibility rests with the contractor. NASA has resident inspectors on site and they approve the procedures used by the contractor and do double checking of the inspection by the contractor in certain cases; not in all details, but they do bear the final responsibility.

Mr. GURNEY. Take the electrical wiring. Tell us how it is done. How do you inspect this and make sure you get proper quality control which wasn't obtained? Can you tell us a little bit about it?

Mr. WHITE. Yes.

Basically the inspection process involves comparing the manufactured article with the engineering requirements to be sure that the engineering requirements have been fulfilled.

In the case of the wiring, the engineering criteria, standards for installation of the wiring, were in some cases not complete and the inspectors use their knowledge of accepted practices to determine whether or not the wiring installation was satisfactory.

Mr. GURNEY. Here the deficiency was a lack of guidelines to determine whether it came up to the proper standard?

Mr. WHITE. That is correct.

Mr. GURNEY. Who was responsible for furnishing that?

Mr. WHITE. The basic responsibility rests with the contractor.

Mr. GURNEY. In this case the contractor didn't lay down the standards and NASA didn't follow up?

Mr. WHITE. Yes, sir.

Mr. DOWNING. Baron was a quality-control inspector for North American and he cited numerous irregularities and defects which he tried to point out. Did he report to the NASA quality-control inspector at the plant site?

Mr. WHITE. I really couldn't say. I am not that familiar with Mr. Baron's position.

Mr. TEAGUE. Would the gentleman yield to me?

Mr. DOWNING. Yes.

Mr. TEAGUE. We will have the director of quality control from North American, and we will have their chief of quality control from Cape Kennedy.

Mr. GURNEY. If we can just complete the wiring example, we have gotten as far as a lack of set of standards. Where do we go from there? Were there any deficiencies in quality control of the installation?

Mr. WHITE. Quality people inspect what the manufacturing department has produced. When they didn't have proper criteria against which to evaluate the manufactured article, they used their judgment. When they found something questionable, they would write it up as a squawk, it is a form they use commonly called a "squawk," and bring it to the attention of the engineers.

The engineers would label it acceptable or bring it up to higher authority.

Mr. GURNEY. Did this extend to anything further than the lack of standards?

Mr. WHITE. I think that is the basic problem.

Mr. GURNEY. What other quality-control problems did you find in the spacecraft?

Can you cite us other examples?

Mr. WHITE. There were some slight deficiencies in filling out the necessary paperwork. I would say these were not serious. They were of the nature that you might find in any comparable program. None of the system operates perfectly since there are human beings involved, but I think the lack of standards is the basic problem.

Mr. KARTH. Isn't it true, Mr. White, while quality control is extremely important, in fact a vital component, it is extremely difficult to have good quality control when you have a badly designed product? Quality control is fine when you have specifications that are very strict and rigid and must be met, and can only be met if adequate inspection is made. It seems to me that quality control is extremely difficult to achieve if you have a badly designed product to begin with.

Mr. WHITE. We have to differentiate between "quality control" as a department within a plant, and the quality of the end product. "Quality control" is comparing the final product with the engineering requirements. If the requirements are not satisfactory, the product quality may not be satisfactory.

Mr. KARTH. In this particular instance under 10 it seems that quality control is superfluous. If it is designed poorly, I don't think quality control does anything but makes the poor design poorer.

Mr. WHITE. It allows poor quality to continue to exist.

Mr. GURNEY. Were there then other poor quality-control procedures besides the electrical wiring?

Mr. WHITE. Insofar as the established procedures are concerned, I believe they were adequate. I don't think we found a deficiency in established procedures. There was a lack of rigor in following the procedures. The plan was adequate.

Mr. GURNEY. You think there were poor inspection procedures with individuals not fulfilling their jobs in quality control.

Mr. WHITE. It is a judgment being made on the unconservative side in many cases.

Mr. GURNEY. In the quality-control procedures and inspections, I understand the primary responsibility is with the contractor to lay them out, to lay out his quality-control program and then for NASA to check to see if that was adequate as far as the plan and procedures are concerned.

Mr. WHITE. That is correct.

Mr. GURNEY. Then to check to see if the job is done under the procedure.

Mr. WHITE. That is correct.

Mr. GURNEY. The Board felt all these things were deficient in some respect?

Mr. WHITE. Yes.

Mr. RYAN. On that question, I am concerned about the answer which has been made by several of the witnesses tonight to the effect that the basic responsibility rested with the contractor. It would seem to me that

the ultimate and final responsibility should rest with NASA who, after all, ordered the work done. They had a responsibility to see whether or not it was sufficient and adequate.

Mr. WHITE. I would like to correct the impression that I might have left when I used the work "basic." The ultimate responsibility is NASA's.

Mr. RYAN. Do you concede NASA failed in its responsibility to properly inspect the design and manufacture and the installation of the electrical wiring?

Mr. WHITE. Yes, to the extent that the deficiencies remain.

Mr. RYAN. Deficiencies resulted; that is the reason we are all here.

Mr. FULTON. The question comes up as to the procedures that that type of information can get to the astronauts. None of you astronauts knew anything about these deficiencies in workmanship and quality control existing in the command module design, did you?

Colonel BORMAN. Yes, sir. I was a backup crew member for the sister spaceship. Last year I was spending most of my time at Downey going through tests. We realized we had problems, and we expected them, but we thought they had been coped with and that adequate protection was being provided in the development program.

Mr. FULTON. You were unaware that this had occurred; is that not correct?

Colonel BORMAN. What, sir?

Mr. FULTON. Deficiencies existed in the command module design, workmanship and quality control such as (a), (b), (c), (d), (e), (f), and (g).

Colonel BORMAN. We were aware they existed. I believe they were being considered and coped with, but obviously we didn't cope with them at all.

Mr. FULTON. The answer is now that after there is a special, careful examination, we can see that they have not been corrected, nor the levels of design of safety or quality control met.

Colonel BORMAN. You are again approaching the idea of an inspector general.

Mr. FULTON. No; I am not.

Mr. WEBB. May I have 30 seconds?

Mr. FULTON. I want to find out the responsibility the astronauts have and what the method of communication is, because I don't want them to be at the end of the rope with no knot.

Colonel BORMAN. The environmental control unit was removed from this spacecraft on the 27th of October and again around the first part of December. The second time it was removed was because five drops of coolant fluid were found on the floor underneath it. Because of this, the environmental control unit was removed and sent back to the contractor.

The people were trying to do their best, but they obviously didn't correct all their deficiencies. There is no question in my mind that the wiring in Spacecraft 12 left much to be desired.

Mr. FULTON. My point is that since that is the fact, No. 1, you astronauts didn't know it; and No. 2, you actually had no means of finding it out on your own initiative.

Colonel BORMAN. This is one of the other things, if I may say about NASA. I have never been excluded from any meetings. We have been

to all the design reviews. We know pretty much the pulse of the spacecraft. It is not of significance that the astronauts didn't know it.

The entire organization didn't realize the essential seriousness or the potential problem. May we hear from Mr. Webb?

Mr. WEBB. If this had not taken place—

Mr. TEAGUE. You have not been recognized. We have about 40 minutes.

Mr. MILLER. Mr. Chairman.

Mr. TEAGUE. Well, let me finish.

We have about 40 minutes. We have some other questions. Before this is over you can talk as long as you want to.

Mr. MILLER. I will save my time for Mr. Webb.

Colonel BORMAN. May we have the next slide?

Mr. GURNEY. Let me ask a couple of questions before we get away from this.

How often do NASA Quality Control people make a thorough inspection of a contractor's operation?

Mr. WHITE. This is done on a continuing basis. Actually a large crew of NASA people in the plant—

Mr. GURNEY. I know there are people right within the plant. I am asking what about a fieldman or supervisor coming around to see that they are doing their job?

Mr. WHITE. There are audits made by the Manned Spacecraft Center people of the contractor's operation.

Mr. GURNEY. How often?

Mr. WHITE. About every 6 months, I believe.

Mr. GURNEY. Is it felt that is not enough?

Mr. WHITE. I don't believe more frequent audits would solve the problem. It is more a matter of correcting the day-to-day operation.

Mr. GURNEY. Is this a thorough audit? Do you have unexpected visitations?

Mr. WHITE. These audits that I mentioned are not unexpected. They are planned and they go into the contractor's operation very deeply.

Mr. GURNEY. If you are expecting something, sometimes you get ready for it; if you are not expecting it, sometimes you don't.

Mr. WHITE. The presence of the NASA people in the daily operation should check adequately on the daily operations.

Mr. GURNEY. Isn't it possible for people working side by side—you know, nobody likes to be regarded as a snooper or too much of a checker-upper—sometimes need to be prodded by somebody else that is a little farther away from the scene?

Mr. WHITE. I admit this possibility exists. However, quality people are by nature snoopers. They are used to being held in contempt by the people they work with.

Mr. GURNEY. They get used to their role.

Mr. WHITE. Yes.

Mr. GURNEY. Suppose a quality control person in North American said, "This wiring isn't good," and the engineer says, "Yes; it is."

What happens at that stage?

Mr. WHITE. Ordinarily the engineer's action would close the item

Mr. GURNEY. Do the engineers override quality control people?

Mr. WHITE. I wouldn't use the word "override." Quality operation is—

Mr. GURNEY. You mean there are trade-offs.

Mr. WHITE. Quality control is assuring that the engineering requirements have been met. If the engineer says they have been met, then quality control backs out and say it is OK.

Mr. GURNEY. Were there any instances where the quality control prevailed instead of the engineer saying it is all right? Did that show up?

Mr. WHITE. Not to my knowledge.

Mr. RYAN. May I ask a question about item No. 10, paragraph (g), "No design features for fire protection were incorporated"?

Colonel BORMAN. Yes, sir.

Mr. RYAN. Did you discover whether or not the possibility of fire had ever been discussed by those who were designing the spacecraft?

Colonel BORMAN. The prime method of extinguishing fires on board in orbit was to depressurize. The method of combating fire was to expose the spacecraft to a vacuum. We had the same problem with Gemini VII where a great deal of time was spent in flight suits, not in pressure suits, so you could not expose a spacecraft to vacuum to extinguish a flame.

The next recommendation is to provide an auxiliary breathing outlet to protect the crew from toxic fumes during the flight.

Mr. RYAN. Was it considered and discarded for any reason, whether for speed or haste?

Colonel BORMAN. Not as far as I know. We did not do it on Gemini VII. We did not consider the risk significant enough to provide the additional means.

Mr. WINN. Speaking of speed and haste, Mr. White, I would like to ask you, in your review of quality control procedures and inspections, did you find any indications of trying to proceed too fast on the part of either NASA or the contractor? You mentioned some forms that were not filled out. What do you attribute that to?

Mr. WHITE. I don't believe that lack of adherence to some of these standard operating procedures was a matter of haste or schedule pressures. It was a matter of overlooking something that should have been done.

Mr. WINN. Would you consider this sloppy workmanship on the part of the inspectors or NASA? If there are forms to be filled out, there must be a reason for this, and you said some—

Mr. WHITE. Apparently a lack of discipline.

Mr. WINN. Who oversees this discipline?

Mr. WHITE. The overseeing, the supervision, is done by the first line supervision of the contractor, but, again, is doublechecked by the NASA quality people on the spot. It is a shared responsibility.

Mr. WINN. If they both don't fill in the forms and nobody calls it to somebody else's attention, then who is the next guy that puts his thumb on it?

Mr. WHITE. It rests first with the NASA quality people on site in the plant. They, in turn, report to the quality people in the Program Office at the Manned Spacecraft Center.

Mr. WINN. Then as I understand it, there was negligence somewhere just on this small part?

Mr. WHITE. Yes; the lack of applying the necessary discipline.

Mr. WINN. Thank you.

Colonel BORMAN. Next slide recommendations:

(a) We recommend an in-depth review of all elements, components, and assemblies of the environmental control system to be conducted to assure its functional and structural integrity and to minimize its contribution to fire risk.

(b) Present design of soldered joints in plumbing be modified to increase integrity or the joints be replaced with a more structurally reliable configuration.

(c) Deleterious effects of coolant leakage and spillage be eliminated.

(d) Review of specifications be conducted, three-dimensional jigs be used in manufacture of wire bundles, and rigid inspection at all stages of wiring design, manufacture, and installation be enforced.

(e) Vibration tests be conducted of a flight-configured spacecraft.

(f) The necessity for electrical connections or disconnections with power on within the crew compartment be eliminated.

(g) Investigation be made of the most effective means of controlling and extinguishing a spacecraft fire. Auxiliary breathing oxygen and crew protection from smoke and toxic fumes be provided.

Next slide:

The Board found (11):

An examination of operating practices showed the following examples of problem areas:

(a) The number of the open items at the time of shipment of the command module 012 was not known. There were 113 significant engineering orders not accomplished at the time command module 012 was delivered in NASA; 623 engineering orders were released subsequent to delivery. Of these, 22 were recent releases which were not recorded in configuration records at the time of the accident.

(b) Established requirements were not followed with regard to the pretest constraints list. The list was not completed and signed by designated contractor and NASA personnel prior to the test, even though oral agreement to proceed was reached.

(c) Formulation of and changes to prelaunch test requirements for the Apollo spacecraft program were unresponsive to changing conditions.

(d) Noncertified equipment items were installed in the command module at time of test.

(e) Discrepancies existed between NAA and NASA MSC specifications regarding inclusion and positioning of flammable materials.

(f) The test specification was released in August 1966 and was not updated to include accumulated changes from release date to date of the test.

Mr. WAGGONER. Colonel, were the NASA astronauts informed or aware, or should they have been made aware of, if they were not, of the findings that you have just described to us in sections (b), (d), and (e)?

Colonel BORMAN. Sections (b), (d), and (e); let us take (b) first. I am sure that the flight crew was aware of the fact that the constraint list was not signed. We have representatives at the meetings when the constraints list is gone through. In this particular case an oral agreement was reached, although the formal part was not completed.

(d), the crew could not help but be aware of this. As you may well be aware, we try to control the configuration so we reach the

ultimate configuration at the time of launch. We don't go through every test with the spacecraft in the condition in which it will be launched. As an example, we have protective covers around the umbilicals. In this case they were flammable.

Mr. WYDLER. You are criticizing it.

Colonel BORMAN. We overlooked the possibility of a spacecraft fire. As I said before, although I would have been very willing to run this OCP at that particular time, after seeing what happened and realizing the possibility that we have with combustibles, I certainly wouldn't do it now.

Mr. WYDLER. How about paragraph (e)?

Colonel BORMAN. The discrepancies that existed between North American and NASA MSC specifications regarding inclusion of and positions of flammable materials. I am not sure that the crew would be aware of it, because of the basic lack of concern or understanding of the hazard of a fire on the ground.

The differences were primarily, in the fact, that NASA's regulations or expectations were more stringent regarding positioning of flammable materials.

Mr. DAVIS. May I ask this question: Any time that you need to make a connection between a component that uses electrical current with a power-on situation, you almost always get arcing. I notice in the previous slides you recommended that that type of situation be avoided.

Colonel BORMAN. It is in Block II.

Mr. DAVIS. How many times did it occur in Block I?

Colonel BORMAN. Every time you removed the communications cable you actually make or break a connection that has power on it. When you unplug or plug in the television you make one. This was not used during this particular test. A television was not powered. These plugs required making or breaking when power was on.

Mr. DAVIS. That was onboard?

Colonel BORMAN. Yes. This has been corrected in Block II.

Mr. DAVIS. Is there a significant difference between making and breaking a connection of 115 alternating current and 28 direct current?

Colonel BORMAN. I don't like to make or break any of them when they have power on them. I don't think it is good practice.

Mr. DAVIS. Is it a big problem? Will it be a big problem in Block II to avoid the necessity of doing it?

Colonel BORMAN. It is already done.

Mr. FULTON. Under paragraph (f) it states the test specification was released in August 1966 and was not updated to include accumulated changes from release date to date of the test.

I previously asked you on the pictures of these astronauts going over their material in preparation for these tests whether it was all up to date when they were studying it; was it kept up to date?

I was a bridge officer in World War II, and one of the worst situations we ever got into was a mixture of old and new. Here, under paragraph (f) it looks as if there was a mixture of old and new so that some of them were up to date and others were not. How can you operate when everything is not all up to date and everyone not briefed when you come up to a certain point of testing?

Colonel BORMAN. We may be confusing the test specifications with the operational procedure. Test specifications tell you what to expect

from certain instruments and readings. This was not updated. That was poor practice.

Mr. FULTON. When the astronauts are being briefed, they will have to know the capability of the instruments and the components. If they are not briefed in that they ought to know, certainly, it shows examples of not having current practices right up to snuff and up to date.

Going to paragraph (a), I understand in Mercury they sometimes had 900 to 1,000 change orders already passed on them. Is that customary in the development of the program, that so many engineering change orders are already at hand at the time of delivery?

One other point is at the very end that these 22 were recent releases that were not recorded in configuration records at the time of the accident.

It would look as if the material is not up to date, not available and part of it is there and part of it is not. Would you comment on that?

Colonel BORMAN. Yes, sir.

I think the mere numbers of engineering orders are not particularly indicative of an incomplete spacecraft. After all, how many is too many in this case? More significant is the fact that the paperwork at the time was not completely aware of the configuration of the spacecraft. In some cases we didn't know how many were open. The only inference you can draw from it is that the paperwork was not keeping up, in some cases, with the hardware.

Mr. FULTON. The paperwork either means something or else it is behind. The paperwork should go along at the same time so the controls are there. If you comment on the last sentence, 22 were recent releases which were not recorded in the configuration records at the time of the accident.

How do you explain that?

Colonel BORMAN. We were not keeping up with the hardware. John Williams, is that a fair statement?

Mr. WILLIAMS. Twenty-two were released from Downey. It was in the process of being put on the list. It showed up on the next list. It is the serial time required from the release of the engineering order to where it is shown in the records.

Mr. FULTON. Does that mean that the EOS were not available for the personnel or does that mean that the bookkeeping wasn't done in some other place?

Mr. WILLIAMS. It means that it takes a certain amount of time to get the EO's into the system at the Cape. It would point to the fact that EO's were in the system but were not in the records to be worked.

Mr. FULTON. At the time of the test, were all the necessary inputs ready, available and on board with everybody having knowledge of them? Or were part of the records not available, so that the test was run with most of the material available but not all?

Mr. WILLIAMS. As soon as the 22 EO's were put in the configuration record, the next week you would have more. They were released from engineering but not placed in configuration system.

Colonel BORMAN. Mr. Fulton is concerned that this had some effect in the running of the test.

Mr. WILLIAMS. No, sir.

Dr. THOMPSON. This is dealing with a matter that is a little difficult to assess a test. He would be operating to a certain extent on grievances

not all written down but it is on knowledge that he has gained and he is judged to be adequate to proceed. We thought we saw quite a lot of what we call informality. I would say in regard to a test conductor, this is very difficult and I had a head count made to see how many people are actually involved in the operation at the time of this accident. And the figure I obtained was 959 people were actually engaged in the test at the time. I don't think it is too surprising that there was in this flow of information to all the participants some informality or some lack of confirmation. We thought it looked a little excessive. Nobody expected the paperwork to be always perfect. The test conductor has a big army of people. He has a responsibility for proceeding and he has to make some judgments and try to assess the rest. When he is dealing with unknown he may be on a little shaky ground to properly assess those risks.

Mr. FULTON. Are all the factors of input ready and available at the time of test? What kind of a timelag is involved in a failure to meet this deadline? (Mr. Hunt has asked this question.)

Mr. WINN. I asked the question.

Mr. TEAGUE. Mr. Winn asked the question.

Dr. THOMPSON. What did you want to know.

Mr. WINN. I asked a question based on F. Someone said they were put in computers. We found it didn't end up in the manual for the tests.

Mr. WILLIAMS. I was talking about A. I was talking about the 22 recent releases which were not recorded. It takes time.

Mr. WINN. What would the timelag be?

Mr. WILLIAMS. I don't have it, I will get the answer.

(Information requested is as follows:)

The best recorded time for a North American spacecraft engineering order to be received and recorded in the Configuration Verification Record Book is two days after release in Downey. The average time is between five and seven days.

Mr. HECHLER. Mr. Chairman.

Mr. TEAGUE. Mr. Hechler.

Mr. HECHLER. I would like to ask Colonel Borman a quick question about the procedure and attitude of the Board on these deficiencies. I think one of the strongest parts of the reports is that you have been frank and critical about some of those operating practices that need improvement.

Taking this group that you have now on the screen, just how do the members of the Board approach a thing like this. Do some of them have additional things that they feel ought to be added.

Colonel BORMAN. How did we arrive at the final findings, recommendations and so on?

Mr. HECHLER. Are there some members of the Board that would like to add some individual recommendations?

Colonel BORMAN. We have been over them a number of times, but if they have any, I will be happy to yield. We have considered these very carefully. I think we have unanimous agreement on all of them. Is that correct?

Does that answer your question?

Mr. HECHLER. Yes.

Mr. DADDARIO. Colonel Borman, if we might go back to the finding, emergency fire rescue and medical teams were not in attendance, as I recall. The report says that the pad leader came to the ground and

advised the three doctors that the three men were dead. My question goes to the three doctors who were there. Were they there in an official capacity or were they just bystanders? What was their function? What were they to have done? What function did they perform?

Colonel BORMAN. Two doctors were in an official capacity monitoring the crew's biomed recordings in the blockhouse. The other was a Pan American doctor. Two were there. At the time of the alarm.

Mr. DADDARIO. Is the fact that they were in the blockhouse partly explained by what you said previously in answer to some questions that you did not expect this kind of hazard to occur in the space capsule?

Colonel BORMAN. This is their normal duty monitoring in the blockhouse.

Mr. DADDARIO. Because they were in the blockhouse and that far away from the capsule, they were not in a position to give some emergency assistance to these men. They did die of asphyxiation. If they were able to be there immediately, if they were on the platform, they would have, I expect, normally taken the necessary steps to see if they could have revived the three men.

Colonel BORMAN. The normal crew egress team does not include a doctor. The theory is to get the crew as rapidly as possible away from the disaster area to an area where medical support is available.

Mr. DADDARIO. Do you mean by that, in the light of the accident which has occurred and the nature of the circumstances surrounding the death of these men, that you are not now recommending that there be medical men available to immediately apply their medical skills and ability to revive men under these circumstances in the event such a tragedy again occurs?

Colonel BORMAN. I think you will find we recommended that they be available.

Mr. DADDARIO. That is A. When you say available, from what you have just said, the function of these men being a different one, that the men would be taken away as quickly as possible from the scene of the tragedy and brought to another place. Would you still say that would be the recommendation you would make when you say that medical teams would be available or that they would actually be on the platform and able to immediately give medical attention in case it was immediately necessary rather than to have them transported to another site.

Colonel BORMAN. I am not responsible for this in NASA. Perhaps Dr. Berry can answer it. I can say from a particular point here just being available, being on site doesn't put them in a position to render aid. These people are in space suits. They are in a spacecraft and we have specially trained people who are there to get them out. The team does not include doctors.

Mr. DADDARIO. On that point I would disagree with you. I wonder if someone might give me their point of view on that.

Dr. THOMPSON. I don't have a point of view on all procedures. We did not try to redesign, to tell what all the procedures should be. There are other times when hypergolic fuels are there that go beyond the risk of this particular state. At various times various people will have risks. What will be worked out—it goes way beyond what the Board has attempted to do. We are not being very specific just where people have certain capabilities should be, we think there should be a decided improvement in the procedures that are applied to these cases.

Mr. DADDARIO. You did determine that these men died of asphyxiation.

Dr. THOMPSON. Yes.

Mr. DADDARIO. If I understand correctly and I have gone into this question from a medical point of view, men under these conditions, if they receive medical attention within a certain period of time, can and have been revived. I would expect that under these circumstances this would be a normal question for your Board to have asked. What was the condition of the men at this time? Would medical attention have helped them? Would this be a proper procedure to incorporate in your findings and in your recommendations for the future?

Dr. THOMPSON. What I learned about it and not knowing anything about it prior to this, is that medical attention of the right type with the right equipment applied soon enough could have saved the astronauts and all those things have to be tied together. Just the mere presence of a doctor along might not have helped materially. If there is other equipment that he has available to treat the victims properly, he could do things that he couldn't do by himself.

I am getting out of my field because I don't know anything about my subject except this is what I have learned. If you want to go into all the procedures that would be appropriate, I think we really would have to talk to other people. Dr. Berry is here. He is in charge of the medical program for the astronauts but I rather doubt that he has completely, or he may have, I don't know, come up with a plan that is appropriate for all the conditions that will occur.

Mr. DADDARIO. I am not able by any means to come to the conclusion that if a medical man were there he might have been able to apply his abilities to attempt to revive these men. But, my question is properly within the nature of your finding in that you found that when the emergency occurred, medical and rescue teams were not in attendance. I assume your Board has come to the conclusion if they were in attendance they might have been helpful.

Dr. THOMPSON. That is what we understand, if we could have got at the victims much sooner with doctors, we might have saved them.

Mr. DADDARIO. If you had doctors on the pad and if the right kind of equipment was there, as you recommend in your findings, these men could have been saved.

Dr. THOMPSON. If they could have been gotten out soon enough.

Dr. SEAMANS. By the time the hatch was opened the medical team would not have helped?

Dr. THOMPSON. It took too long to get them out of the spacecraft.

Mr. WYDLER. Would the gentleman yield to me?

Mr. DADDARIO. Just one moment.

When you say that, what period of time are you talking about? I don't have it right before me, I think I could check back.

Dr. SEAMANS. I was just asking a question to clarify the point.

Mr. DADDARIO. The figures do not indicate themselves the period of time when men being asphyxiated could not be revived. It was a very chancy proposition that they were or were not within the range where they were capable of being helped.

Mr. MILLER. I suggest that you direct your questions to Dr. Berry. This is a medical question.

Mr. DADDARIO. I would be very happy to, Mr. Chairman. I am undertaking this line of questioning because it seems to me that it falls with-

in the scope of this Board finding, I would be very happy to question Dr. Berry on another day.

Dr. SEAMANS. Dr. Berry is here if you care to have him answer the question.

Mr. DADDARIO. Could you take my question into consideration, come to some judgment upon the effect it would have to be of help in the future in a situation such as this?

Mr. TEAGUE. Dr. Berry, would you want to answer? Will you be here with Dr. Mueller?

Dr. BERRY. Yes.

Mr. TEAGUE. We will take it up then.

Mr. WYDLER. I understand that the rescue team was on the way to the pad at the time of the accident. At what time did they come on duty that day?

Colonel BORMAN. It is listed in the Panel 11 report. The whole time line is in there. Unfortunately, I don't have it committed to memory.

Mr. DADDARIO. It was not a rescue team. It happened to be two doctors who had other duties and who came because of the tragedy. They weren't there for that particular purpose.

Colonel BORMAN. There was a rescue team on the way to practice an emergency egress exercise to be conducted at the end of the test.

Mr. DADDARIO. Was it not the two doctors who were advised by the pad leader that the crew was dead?

Colonel BORMAN. Yes, sir.

Mr. RYAN. May we revert to finding 11 and the statement that there were 113 significant engineering orders not accomplished.

Colonel BORMAN. There were more EO's, some were routine such as making sure initiators were not in the escape tower.

Mr. RYAN. Why were they accepted?

Colonel BORMAN. It does not mean the spacecraft is incomplete.

Mr. RYAN. This says 113 significant orders were not accomplished.

Colonel BORMAN. We classified as significant orders those that involved manufacture or work on a spacecraft as contrasted to routine orders that were to accomplish things like removing pyro's, safing pyro's, and so on.

Mr. RYAN. With hindsight, would you say it was proper to have accepted the spacecraft with those orders unaccomplished?

Colonel BORMAN. This is an area you should discuss with the program management and the people responsible for accepting the spacecraft.

Mr. RYAN. Who is that?

Colonel BORMAN. Dr. Mueller and the Apollo program management.

Mr. RYAN. Was Dr. Mueller aware that these were not accomplished?

Colonel BORMAN. You ought to defer that for Dr. Mueller to answer.

Mr. RYAN. What did the Board find?

Colonel BORMAN. The Board found this. We didn't ask Dr. Mueller. We found the spacecraft had that many open items on it.

Mr. RYAN. How many spacecraft were delivered to NASA?

Colonel BORMAN. This was the first manned spacecraft delivered.

Mr. RYAN. This was the first one delivered to NASA. The paperwork was not up to date enough to show that.

Mr. GURNEY. In the conduct of your investigation I understand you took apart spacecraft 14 in order to see how that worked in order to—

Dr. THOMPSON. We took several of the components out as an exercise in determining how to take them out of the other spacecraft.

Mr. GURNEY. Did you see any deficiencies?

Dr. THOMPSON. Some of the judgment of deficiencies are based on what we found in spacecraft 14.

Mr. GURNEY. The deficiencies insofar as the whole accident have followed through in the other spacecraft as well as the one that the fire occurred in.

Dr. THOMPSON. We were looking at Block I spacecraft. We understand Block II have been greatly improved.

Mr. GURNEY. I am talking about the one you took apart.

Dr. THOMPSON. We were not particularly pleased with the wiring.

Mr. GURNEY. Thank you.

Mr. DAVIS. I would like to address one question to Dr. Berry or anyone else who wants to answer.

It is a fact that if the human body has a choice between carbon monoxide and oxygen, the lung system that goes to keep the blood supplied with oxygen will overwhelmingly take in carbon monoxide, would it not, to the exclusion of oxygen?

Dr. BERRY. That is true. Its affinity for carbon monoxide is up to 210 times that for oxygen.

Mr. DAVIS. On 5-9 it says the combined effect of these environmental factors, that faced the astronauts, increase the lethal effect of any factor by itself. It is estimated that consciousness was lost between 15 to 30 seconds after the first suit failed. Chances of resuscitation decreased rapidly thereafter and were irrevocably lost within 4 minutes. I take it that 4-minute interval is arrived at because that is about as long as the brain could do without oxygen.

Dr. BERRY. That is correct, that tends to be a maximum limit. It was probably shorter than that.

I would like to go into that later.

I would like to make one point while I have the floor one second. In case anyone has any other idea, this crew could not have been saved by the presence of a doctor or anyone else. The situation was such that that was not possible in this instance. I would like to make that very clear.

Mr. DAVIS. That was the purpose in asking my question.

Mr. TEAGUE. Frank, we are going to stop with you and I am going to recognize Mr. Rumsfeld to question Colonel Strang. Then I am going to recognize the Administrator for whatever time he may desire and then we are going to adjourn.

Colonel BORMAN. May I say one thing?

Mr. TEAGUE. Yes.

Colonel BORMAN. Thank you. [Laughter and applause.]

Mr. RUMSFELD. I am impressed with Colonel Borman's responses. Not only were they responsive, but also concise. I would now like to pose a few questions to the other Air Force representative on the panel.

Colonel, you are with the Office of the Inspector General of the Air Force; is that correct?

Colonel STRANG. That is correct.

Mr. RUMSFELD. What is your official title?

Colonel STRANG. Chief of the Missile and Space Safety Division, Directorate of Aerospace Safety for the Air Force Inspector General's Office.

Mr. RUMSFELD. In Washington?

Colonel STRANG. Yes. My duty station is Norton Air Force Base, Calif.

Mr. RUMSFELD. I have been impressed with the report as far as it goes. Mr. Webb's letter, dated February 23, 1967, stated the Board will consider the impact of the accident on all Apollo activities. This is a broad charge. Did the Board examine NASA's safety analysis and review program to your satisfaction?

Colonel STRANG. I would rather answer that in this manner. We did not examine them all.

Mr. RUMSFELD. Was there any discussion as to whether or not they would be examined?

Were you not, as a member of this Board, distressed that these basic questions were not looked into by the Board in view of the charge given you and the other members of this panel?

Colonel STRANG. I personally obtained the Kennedy Space Center safety directives, and went through them myself; the directives from the Safety Office as written satisfied me.

Mr. RUMSFELD. To put that another way, are you saying from your experience in the Air Force, the NASA safety procedures, from a broad standpoint within management, compared favorably with those you have had experience with in the Air Force? They satisfy you as an official in the Office of the AF Inspector General?

Colonel STRANG. Broadly. Their procedures are not in the detail we have in the Air Force. That is possible because they work with a higher scientific group of personnel than that in the Air Force.

I would like to clarify that, if I may.

Mr. RUMSFELD. Maybe we ought to strike it from the record. I know what you mean. Go ahead.

Colonel STRANG. I think when you are dealing with many thousands of airmen compared to the lesser number of engineers and highly qualified technical personnel that NASA has, there is a great difference and greater detail is required.

Mr. RUMSFELD. It appears to me that none of the panels under this Board were charged with that responsibility, so that this review on your part was done purely as an individual?

Colonel STRANG. Yes.

Mr. RUMSFELD. Colonel Borman said nothing was sacrificed for crew safety. I realize this and applaud it, and am delighted to hear it. He said NASA was always receptive to astronauts' suggestions. I am sure this was the case, and knowing Dr. George Mueller, I am sure this would be the case with him because he is an able and dedicated man.

Are you in any position to throw any light on what structural situations in NASA management led to the restricted input that resulted in the so-called hazard evaluation gaps? Have you been able to detect any situation in the NASA structure that is different from the Air Force's or that doesn't compare favorably with the Air Force's that leads you to believe that some changes in structure would help to reduce the hazardous evaluation gap?

Colonel STRANG. I just looked at the Kennedy Space Center. If I had looked over all NASA I would be required to look at NASA headquarters' directives which I was not capable of doing nor was I charged with it.

Mr. RUMSFELD. Did you come to any conclusion as to how NASA overlooked the possibility of spacecraft fire in this test?

Colonel STRANG. No. In our many discussions on this very point, it was brought out that first the contractor, in designing the test and developing the test, has to determine whether or not it is a hazardous operation.

This, then, is reviewed by NASA to make the full determination.

Mr. RUMSFELD. So once you begin with an erroneous assumption you can proceed logically to an equally erroneous conclusion.

Colonel STRANG. Possibly. Once it is determined to be hazardous then it is processed through the Safety Office. They have certain procedures that they implement to make sure that they have the proper personnel available, firefighters, rescue teams, and all other necessary precautions are taken.

Mr. RUMSFELD. Has the Air Force investigated the potential hazards at 17 pounds per square inch with 100 percent oxygen?

Colonel STRANG. None other than at Brooks Air Force Base. That is the only one to my knowledge.

Mr. RUMSFELD. Do you believe in the principle of an inspector general?

Colonel STRANG. Most certainly.

Mr. RUMSFELD. From the experience you have had in past weeks on the Board, do you feel that an inspector general or an independent safety review board could conceivably be of assistance to NASA in reducing this hazard-evaluation gap?

Colonel STRANG. I think so. I don't know.

Mr. WYDLER. Would the gentleman yield to me?

Mr. RUMSFELD. Yes.

Mr. WYDLER. The accident that took place in the Air Force installation in which your employees were involved also took place under similar atmospheric conditions.

Colonel STRANG. Yes, sir; two airmen died in the oxygen chamber, as we call them, and they were doing some various tests. I don't have all the details with me.

Mr. WYDLER. It was a pure-oxygen situation?

Colonel STRANG. Yes.

Colonel BORMAN. 18,000 feet.

Mr. WYDLER. But pure-oxygen atmosphere?

Colonel STRANG. Yes.

Mr. WYDLER. Was that by the Air Force?

Colonel STRANG. By the Air Force.

Mr. WYDLER. Do you know if that work was being done for NASA?

Colonel STRANG. I don't know.

Mr. DADDARIO. Would the gentleman yield?

Mr. RUMSFELD. How did you make the decision that in the face of Mr. Webb's broad charge to your Board you would restrict the Board's study and investigation to the extent that it was restricted and not go into these broader questions that I have been discussing and that apparently no panel was assigned to investigate.

How did that decision come about on your part or on the Board's part?

Maybe I am incorrect, but as I read Mr. Webb's charges they are broad, to consider the impact of the accident on all Apollo activities. It goes to these broader questions that I have been raising.

Dr. THOMPSON. We had a certain urgency on us to arrive at a position in a pretty prompt manner. We worked out panels to discuss or explore all the areas. You have seen, I think, these panel reports. Each one of those work panels had an assigned task. It was written out for it.

Mr. RUMSFELD. Why wasn't this assigned?

Dr. THOMPSON. It is included in seven.

Dr. FAGET. In seven and thirteen.

Mr. RUMSFELD. Only in a very narrow sense. If you read the findings and determinations and recommendations not one of them goes to the substance of what I am discussing.

Dr. THOMPSON. We interpreted it this way and set up the panels according to the interpretation we made. We submitted those to the Administrator, and we got an approval as to the scope of our investigation, and so we assumed that that is about as far as we needed to go. But I don't see how you can say we were so restricted.

The findings of panel 7 go into local controls provided by certain systems we may require remote control for safety reasons—it goes into several matters that pertain to safety.

Mr. RUMSFELD. They didn't find their way into the 11 conclusions and recommendations.

Dr. THOMPSON. We stated it more broadly in our own findings. We did not go into that much detail.

Mr. RUMSFELD. Thank you.

Mr. TEAGUE. Mr. Webb, would you like to be yielded to?

Mr. WEBB. I will be very brief. I will thank the Board at the present time for their work. I do think they have been thorough. I believe this committee will find that the establishment of the Board was sufficiently broad for them to do their work without restriction or without interference from NASA, but rather with the help of NASA and with many people such as those distinguished officers of the Air Force and from the Bureau of Mines. Let me say, secondly, that it would be a grave mistake in my view to read the report of this Board without recognizing that we are dealing with a very large research and development program, no spacecraft that we have ever flown could meet every requirement in detail so far as the layout on paper of every requirement.

We have developed the kind of capability with an industrial team and in our own NASA in-house technical capability to form judgments as to the risk to be taken and in this case, my own view—at least until I have had an opportunity to more fully and completely study the report of this Board is that much of the attention to risk was centered on the very large explosive power of the fueled booster of the Saturn class. We have not yet learned to live with the tremendous explosive power of one of these large boosters. And I believe a great deal of our attention insofar as risk relates to the need to work near to and around the risks of such large concentrations and all the collateral risks have not yet been fully appraised, even with the work of this Board. Either the country is going to take the risks and get on

as we did in Mercury and Gemini, or we will not have a manned space flight program.

We have the capability to move ahead. We will be prepared. Nobody could feel worse than Dr. Mueller and Dr. Seamans and Dr. Gilruth and me that everything that could save these men's lives was not done.

The Board has pointed in an important way to the necessity of doing everything that has to be done and not leaving any small or limited part of the job undone on any one site, and it seems to me we will need to tighten up our whole effort, but any kind of approach that tends to destroy the system in order to tighten it up will mean we simply won't have a manned space-flight program. This is what I meant when I said we all share a very grave responsibility.

I hope we will not lose sight of the fact that this team has produced success for this country and can again if given the support needed to do so.

Thank you very much.

Mr. TEAGUE. The last person I shall yield to is our chairman, the gentleman from California.

Mr. Miller.

Mr. MILLER. Mr. Chairman, I want to express my appreciation to this Board. I know they are dedicated men who have worked hard and long in a task that none of us would like to undertake.

I recognize their dedication. While we may differ minutely, I think on the whole that they have rendered a great service to the country and a great service to the program. I join with Mr. Webb's evaluation that if we are going to go on with the program, we have got to take some risks. I don't think anyone questions that.

I think the fact that we have made as much progress as we have in the field of space flight, sending men into a hostile environment, living there and returning, indicates that NASA is a viable organization. I hope that we can, in dedication to the three men who gave their lives, go forward with a program to keep faith with them for the sacrifices they have made.

Mr. WEBB. Thank you.

Mr. TEAGUE. The Chair would like to announce that at 10 o'clock tomorrow we will hear J. L. Atwood, president and chairman of the board, North American Aviation, Inc., accompanied by Harrison Storms, vice president, NAA, and president, space and information division, NAA; Dale Myer, vice president, space division and Apollo program manager, NAA; accompanied by Tom McDermott, director of quality and assurance control, space and information division, NAA, John Hansel, chief, quality control (Cape Kennedy), space and information, NAA.

Dr. Thompson, may I add my word of appreciation to you and your Board for a job well done. And thank you for coming here.

The committee will be adjourned until 10 a.m. tomorrow morning.

(Whereupon, at 10:25 p.m., the subcommittee was adjourned to reconvene at 10 a.m., Tuesday, April 11, 1967.)