REVIEW OF THE SPACE PROGRAM

MONDAY, FEBRUARY 15, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met at 10 a.m., Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The committee will come to order.

This morning we are privileged to have Rear Adm. W. F. Raborn, who this committee knows well because of his previous appearances, and Admiral Connolly, who is Assistant Chief of the Bureau of Weapons for the Pacific Missile Range, and we are happy to have both of you gentlemen this morning.

Admiral Raborn is Director of Special Projects, Department of the Navy. We are happy to have you, Admiral, and we will be glad to have your statement.

May I ask you that are going to testify to hold up your right hands. Do you solemnly swear that the testimony you give before this committee in matters now under consideration will be the truth, the whole truth, and nothing but the truth, so help you, God?

Admiral RABORN. I do.

Admiral CONNOLLY. I do.

The CHAIRMAN. At 11:30 the committee will go into executive session because of the special report to be given to the committee at that time. I believe, though, we will have finished with these two gentlemen in open session by 11:30. Now, Admiral Raborn.

Admiral RABORN. Shall I proceed, Mr. Chairman?

The CHAIRMAN. If you will.

Admiral RABORN. With your permission, I would like to submit my statement for the record and I would like to give you a short verbal presentation on our program followed with a short movie which will give you documentary evidence of our progress since the last time I had the pleasure of appearing before your committee.

The CHAIRMAN. Fine. Just in the order in which you wish it, Admiral.

Admiral RABORN. Thank you, sir.

The CHAIRMAN. Can all members of the committee see all right?

Mr. BASS. Yes.

STATEMENT OF REAR ADM. W. F. RABORN, USN, DIRECTOR, SPECIAL PROJECTS, DEPARTMENT OF THE NAVY

Admiral RABORN. Mr. Chairman, as you will recall, the Navy and the Army were partners in an attempt to use a liquid fuel missile

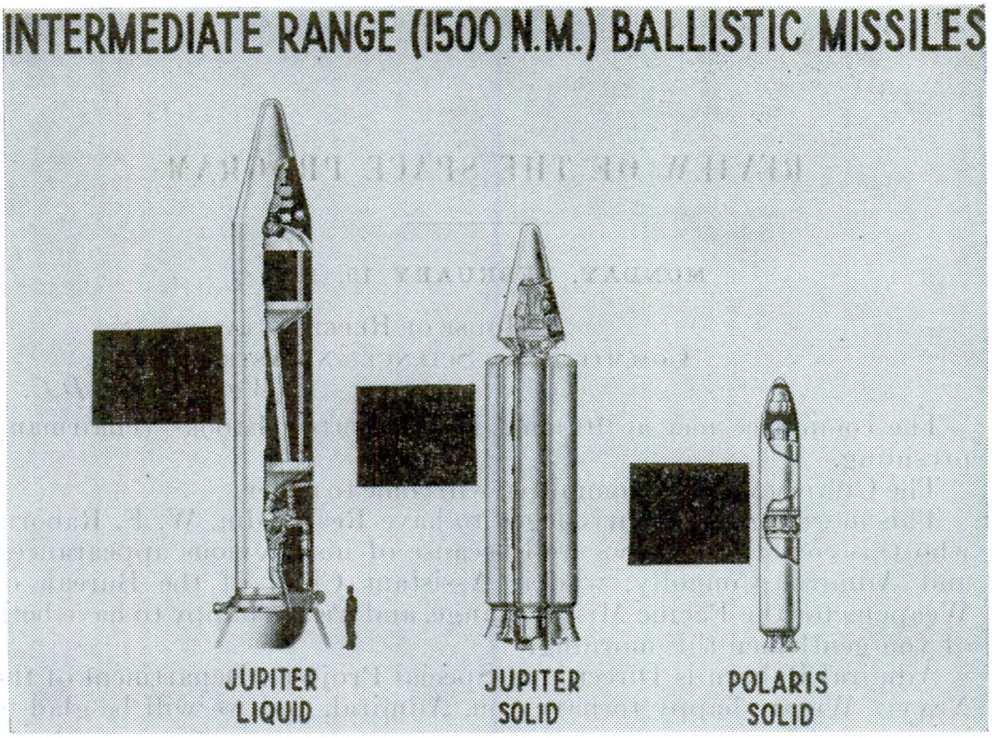

FIGURE 80

which was later named the Jupiter, shown here. After about 8 months of very profitable and happy association, it was determined that the use of liquid fuels aboard the confined spaces on the ships and particularly in submarines would make it infeasible from a point of view of safety (fig. 80).

So we tried to see if we could have a solid propellent missile which would utilize the nose cone and the guidance package of this missile. That is shown here (pointing to fig. 80). We did not build this, but because of its large weight, we found we could get very few aboard a surface vessel. About this time, of course, the AEC had a marked improvement in their warhead yield versus weight. We, in turn, in the Navy had a breakthrough in the amount of specific impulse or energy which we could get out of solid fuels. So it seems natural to tie the two together and we came up with what turned out to be the Polaris solid propellent missile, two-stage solid propellent missile, of marked decrease in size. This is the progression which we made (fig. 81, p. 620).

Next graph: Then the job as we were given it a couple or so years ago was to take the warhead, the solid propellant, develop the solid propellent motor and tie them together with a nuclear powered submarine which is represented by the *Nautilus* here (fig. 82, p. 620).

Essentially then it is to put a solid propellant ballistic missile in a nuclear powered submarine especially built for this purpose. The Navy, as you recall, sir, created a Manhattan district type organization which they called Special Projects.

This organization that it is my privilege to head reports directly to the Secretary of the Navy, and all departments and elements of

the Navy have been requested to support this program on a first-call basis, first priority basis.

The President of the United States has given the Polaris program coequal No. 1 priority to other programs in this category in the United States and being a Manhattan District type organization, our job is a total one. Build the missile, do the research development, production of the missile, build a nuclear-powered submarine, test the missile, provide the personnel, and provide this whole system operational to the fleet (fig. 83, p. 621).

As such, we are weapons systems managers and what we like to think of in the true sense of the word. Because if it has to be done and connected with the Polaris, it is our job. Doing this we have over 3,000 Government agencies and private contractors here which are engaged in this program (fig. 84, p. 621).

Shown on this view graph and I will read it because I know it is probably difficult from the front of the room. The partners which we have, Lockheed at Sunnyvale is the prime missile contractor and subcontracting to it for the motors is Aerojet General Corp. at Sacramento. General Electric at Pittsfield is doing the missile guidance under a subcontract to Lockheed (fig. 85, p. 622).

Lockheed is integrating and tying the whole missile system together, a very necessary job. The AEC, of course, is providing the warhead and the committee, joint committee on this, which is military and civilian, is chaired by a lieutenant commander in my shop.

I am very glad to say that this young fellow was chosen for this job because of his qualifications. He has a doctor of physics degree and is one of the brighter young men, I think, in uniform.

The shipboard navigation system is being done by Sperry, as well as the North American organization in California. There is a growing Government and industry team working on the FBM effort. I think this is a matter of interest that these dots show principal areas of work which are contributing to the fleet ballistic missile or Polaris weapons system (fig. 86, p. 623).

It covers the United States. I think this is significant because I am sure that coming from inland States such as I do, there is a prevalent feeling that when the Navy does work, that most of the benefit goes to States on the sea coast. This, of course, is not true. Next slide, please.

We have nine submarines under construction. Four of these are launched, one is commissioned, that is the *George Washington*, the one that is commissioned. We have three in the fiscal year 1961 program plus long lead time items for three additional submarines in the 1962 program (fig. 87, p. 623).

Next slide, please. The mode of operation is shown here on this view graph, sir, as you know we plan to eject the missile from the submarine underneath the water and start the first motor after it gets out of the water. This, of course, does away with danger inherent in igniting the missile inside of the submarine (fig. 88, p. 624).

It also gives us the stability of a submerged submarine. I was out on the *George Washington* not too long ago on her builder's trial and, Mr. Chairman, I want to tell you it is a beautiful ship. She is steady as a rock. I have been to sea 30 years, man and boy, and I spent a delightful night 300 feet below the surface of the Atlantic. It provides a very stable platform.

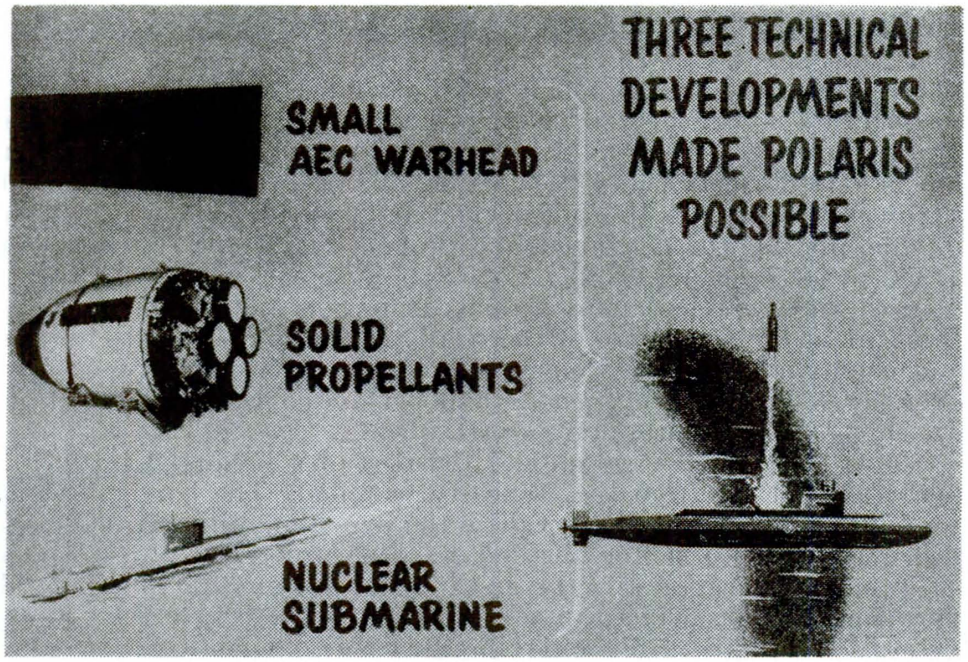

FIGURE 81

FIGURE 82

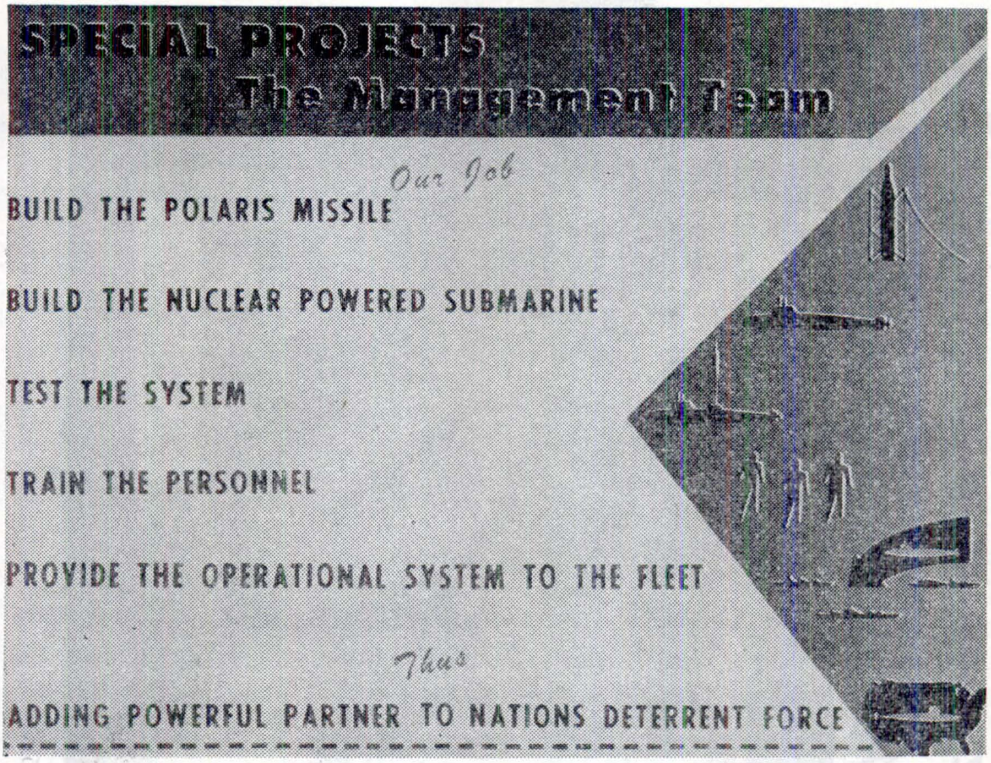

FIGURE 83

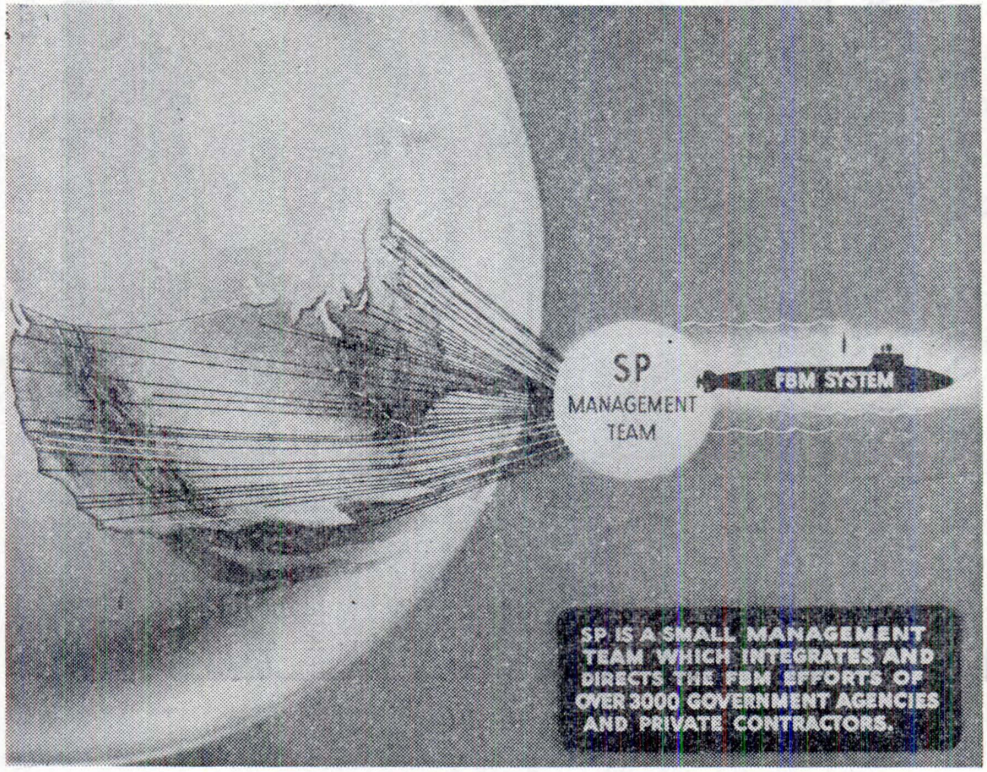

FIGURE 84

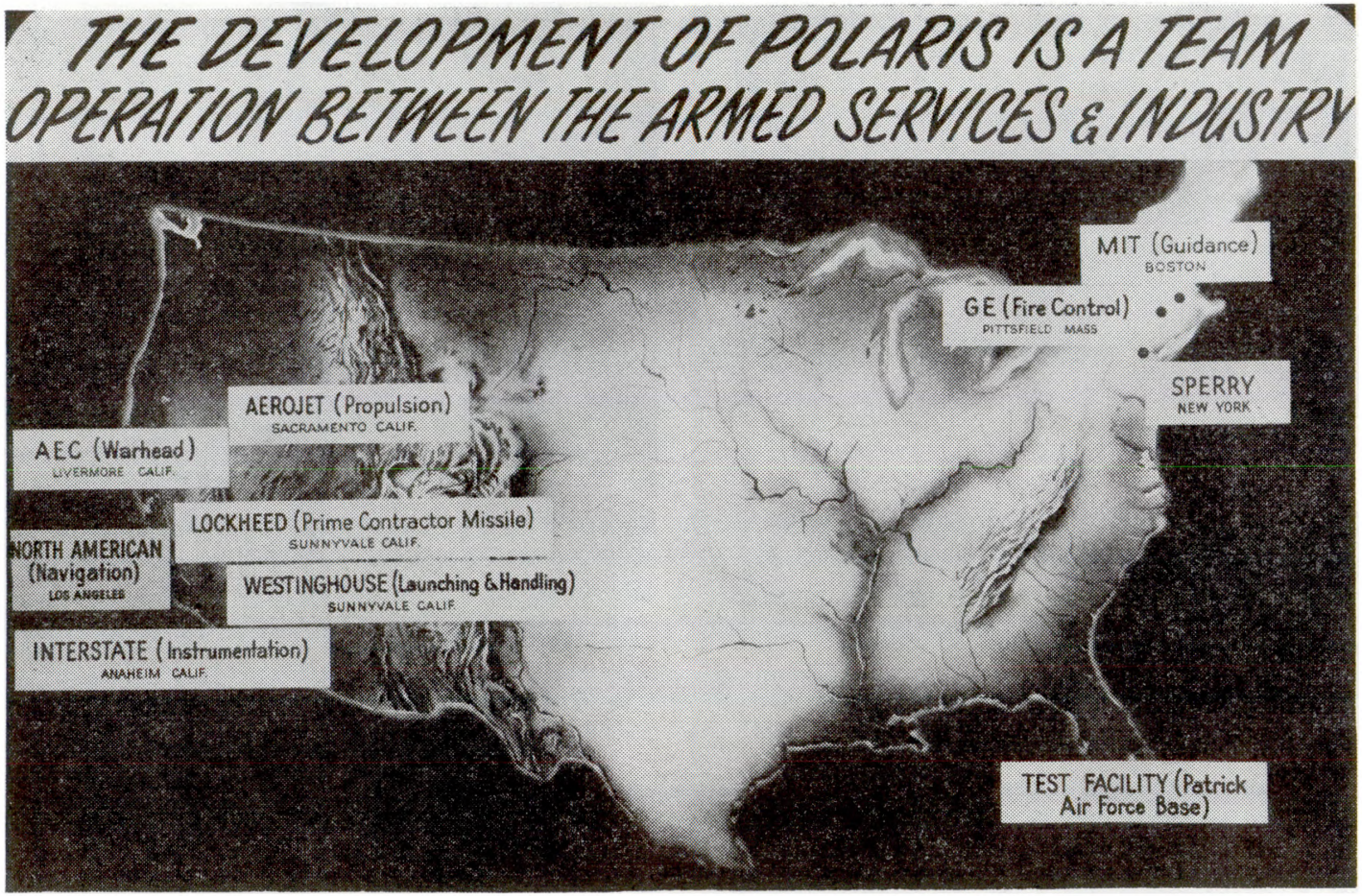
THE DEVELOPMENT OF POLARIS IS A TEAM OPERATION BETWEEN THE ARMED SERVICES & INDUSTRY
MIT (Guidance)
BOSTON
GE (Fire Control)
PITTSFIELD MASS
SPERRY
NEW YORK
AEROJET (Propulsion)
SACRAMENTO CALIF.
AEC (Warhead)
LIVERMORE CALIF.
LOCKHEED (Prime Contractor Missile)
SUNNYVALE CALIF.
NORTH AMERICAN (Navigation)
LOS ANGELES
WESTINGHOUSE (Launching & Handling)
SUNNYVALE CALIF.
INTERSTATE (Instrumentation)
ANAHEIM CALIF.
TEST FACILITY (Patrick Air Force Base)

FIGURE 85

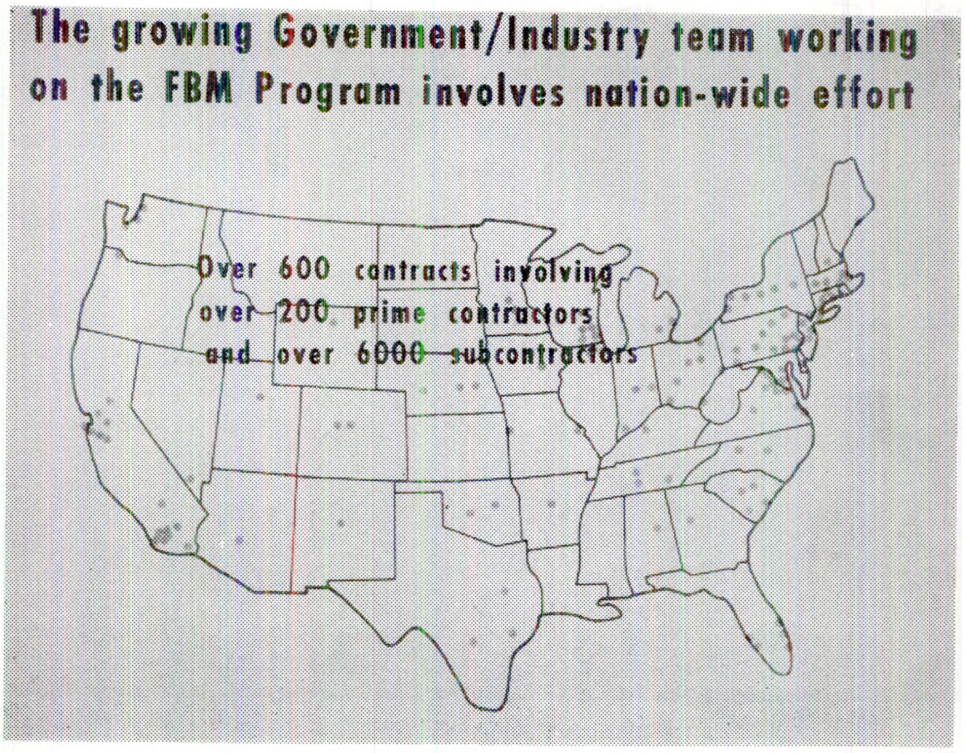

FIGURE 86

We fired a couple of slugs out of the launchers which was a service-like test of the launcher, itself, and the stability of the submarine during this operation was beautiful.

Mr. MILLER. Does it give you a good bang?

Admiral RABORN. No, sir. But the submarine is a large rascal and she is very stable. So we are very pleased with this. In fact, the *George Washington* has lived up to her specifications quite well.

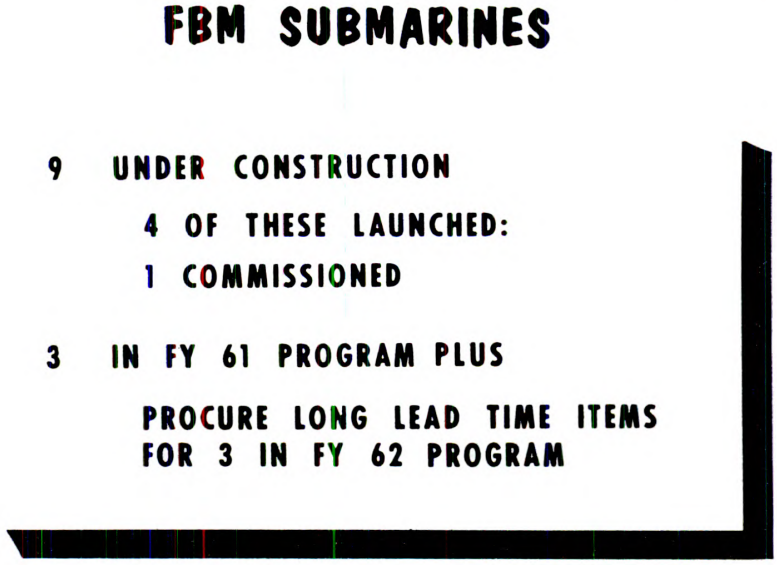

FIGURE 87

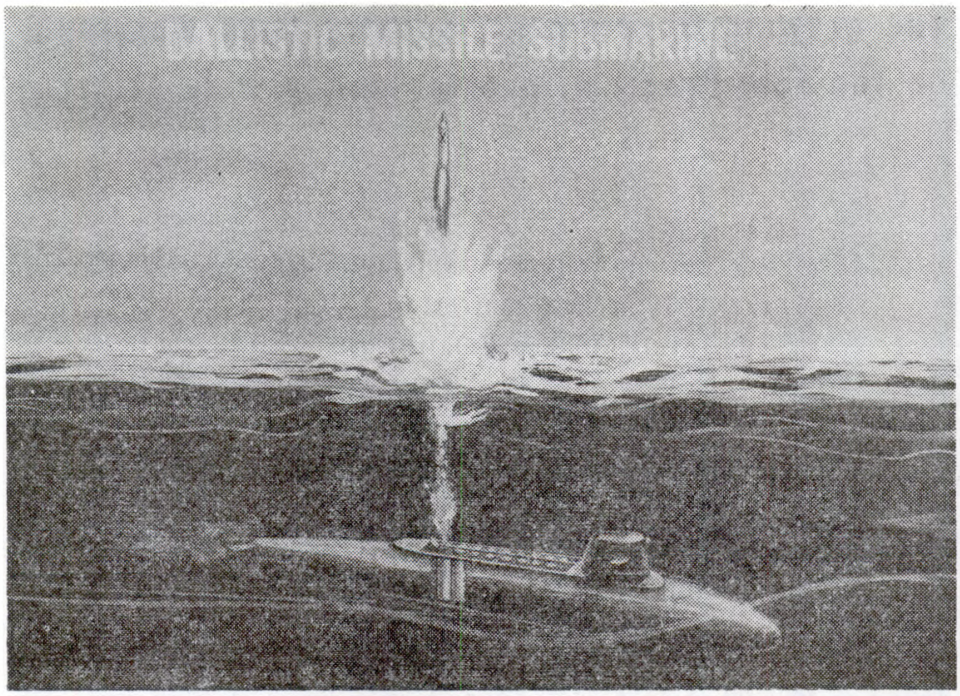

FIGURE 88

The crew, the spirit of the crew on her is tremendous. They are vastly motivated to do a good job (fig. 89).

This is a picture of the *George Washington.* It is a rather unusual one, as you see. The bow is actually to the left here and when she is steaming along, the water comes right on up—on the surface, the water comes right on up here. This is designed to go through the water instead of riding over it like a normal surface craft.

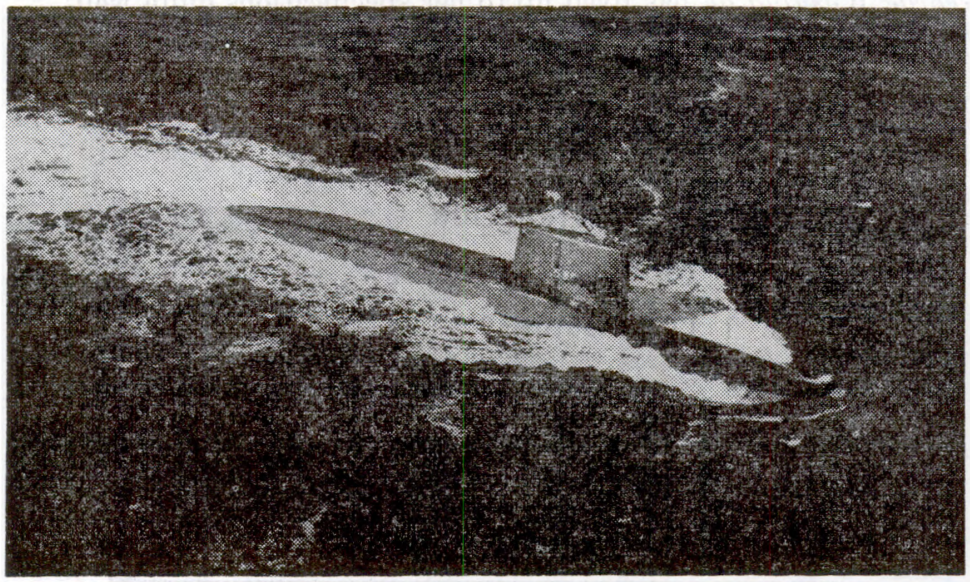

FIGURE 89

Of course, the missiles are housed back in here as you know, giving it that peculiar humpbacked design. Next slide. I would like to tell you a little bit about some of the major work areas which are conveniently labeled here because I think it is of importance that we remember that to bring a whole system like this into being that we have to talk about and do work in, human factors, communications, navigation, fire control, launching, propulsion, guidance, ballistic shell of the missile and, of course, the reentry body (fig. 90, p. 626).

This is a picture aboard one of our nuclear-powered submarines. Captain Jim Calvert who made the first trip underneath the pole. Of course, when we talk about human factors, we have to remember that with these complicated weapons systems, the man is the limiting factor when the machine has gotten past the capability of the man without due consideration as to how to operate them.

I mean by that, without engineering into the equipment a full recognition of the capabilities of the man who is to have to operate it. We have done this and Dr. Jack Dunlap of Dunlap & Associates, has been with me now as my top consultant for human engineering for a period of about 4 years and he has set up industrial engineering or human engineering elements in all of our major contractors and has seen that the equipments, as exotic as they may be, when brought into existence, that the man can use them and use them well.

We found some remarkable lapses from the consideration that the man had to use this and when we did the human engineering, why we made the equipments very acceptable.

Now, we don't stop at just engineering the equipment. We have to remember that when we shut ourselves off from the normal atmosphere of the earth for periods of months, that we are pioneering into many of the problems which space travelers will have to lick if they are going to do the job well.

Certainly, control of the air and the kind of air that we have in there is a major problem. Now, we have gone to great length aboard these ships to keep the air clean. We have scrubbers that take contaminants out of the air and we also have a very methodical far-reaching program to keep unwanted contaminants from getting into the air and to help me in this, I have two medical officers assigned to me by the Chief of Bureau of Medicine and Surgery. They have been with me 4 years now (fig. 91, p. 626).

One is a captain, Medical Corps, who is a long time submariner. The other one is a toxicologist of considerable competence.

Together, they are delving into the physiological as well as the psychological aspects of keeping crews alert and efficient over long time submergence and away from home.

In partnership with the National Institutes of Health and with work being done elsewhere, we have gone into this matter of keeping the air sweet and clean and to keep objectionable contaminants from getting into the air. For instance we have found that certain kinds of cooking oils release unacceptable contaminants to the air. It is necessary that we use another type; lubricating oils simply. Ridiculous as it may seem we have found that some types of aerosol, such as you have in shaving cream—you push a button and out comes a certain amount of shaving cream—we found some of the aerosols used in those cans release highly contaminating and objectionable

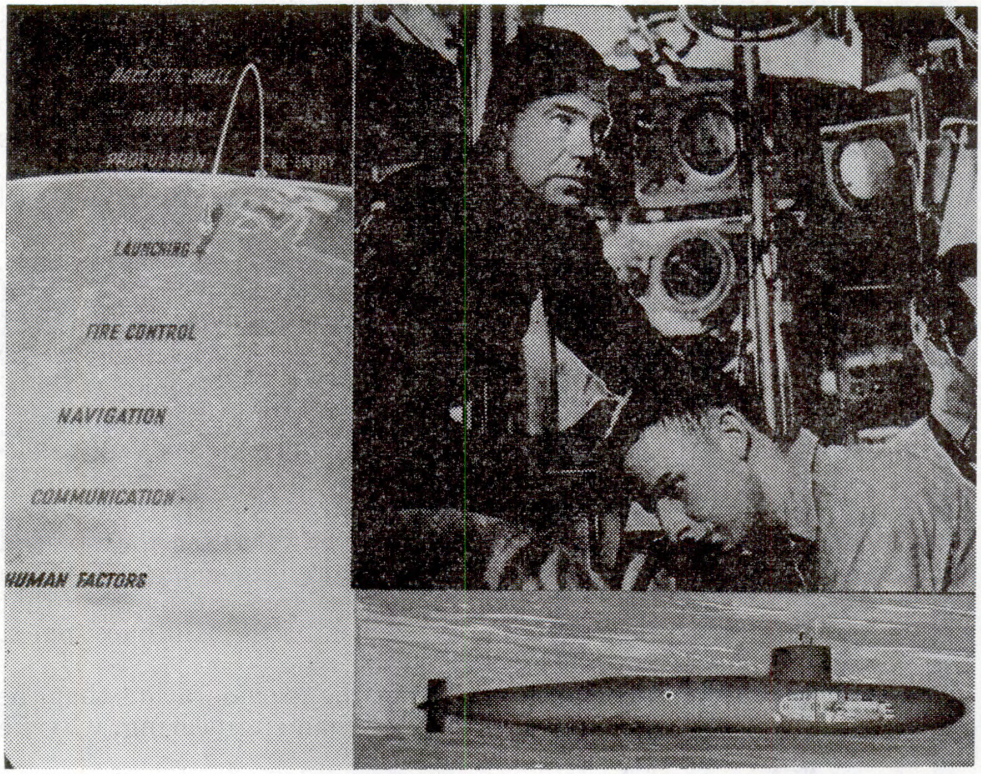

FIGURE 90

FIGURE 91

FIGURE 92

contaminants to the air. Therefore, we just shift the gas and get around this. This sounds ridiculous, but this is the kind of methodical approach to it that we are trying to take. Also, of course, we are looking into the recreation, well-being of the man to keep him happy. I am even trying to find a space for a two-man gym, so people can put on the gloves. Instead of carrying around a pout, they can get it out of their system (fig. 92).

Mr. FULTON. How about an old cigar stub?

Mr. MOELLER. I will put it down right now.

Admiral RABORN. I might say it is rather interesting that submariners—I have sharp pointed dolphins on myself—but submariners, almost invariably, smoke cigars. In fact, the 3 days I was on the *George Washington*, I came back puffing away on a cigar. Of course, they release objectionable contaminants to the air. I don't know what we are going to do about this, except we have these CO_2 scrubbers that clean the air out quite a bit. Perhaps we can have a smoking room.

Mr. FULTON. If you will give Congressman Moeller some dolphins, why that will make him acceptable here. [Laughter.]

Admiral RABORN. This is a picture of the crew mess aboard the *George Washington*. It is very large and quite spacious for a submarine. The food is good, as I can attest for the 3 days aboard and a couple of extra pounds, I believe. But all in all the comfort, the individual comfort of the man, we are looking after it with a great deal of attention. For instance, I have a whole bank of washing machines. A man has his laundry picked up by one of the crew and taken down and washed and nicely ironed and delivered to him. Of course, fresh water is not a critical factor aboard a nuclear powered submarine. You can have all the water you want, which is quite a thing (fig. 93, p. 628).

FIGURE 93

Mr. MILLER. How do the quarters here compare with those on the *Nautilus?*

Admiral RABORN. They are better. We have more space on this ship, it is a considerably larger ship. Our communications are coming along quite well. This is one of the things which we have concentrated on, and one of the responsibilities assigned to me is the effective communications with these ships. We are putting in a very powerful low frequency station shown here at Washington County, Maine, and, of course, this will parallel the other low frequency stations that we have in the State of Washington and in Hawaii and Annapolis and elsewhere.

By means of these communications stations as well as the high frequency stations, we can have these ships under constant communications reception throughout the world. I am very glad to say that we were able to improve considerably on the World War II technique, developed during World War II, of sending a message to a submerged submarine. So there isn't any question in our mind that we will be able to communicate with these submarines on a very effective and acceptable basis (fig. 94).

Mr. MILLER. You couldn't lend that to the Argentines right now, could you?

Admiral RABORN. Yes, sir; they are communicating the hard way there, with depth charges.

Navigation, of course, is another one of our major developmental areas and for this purpose we have had in commission over 3 years a navigational test ship which we converted. It is a converted Mariner; we got it from the Maritime Commission. We have in this all of the equipments which we have aboard *George Washington* as well

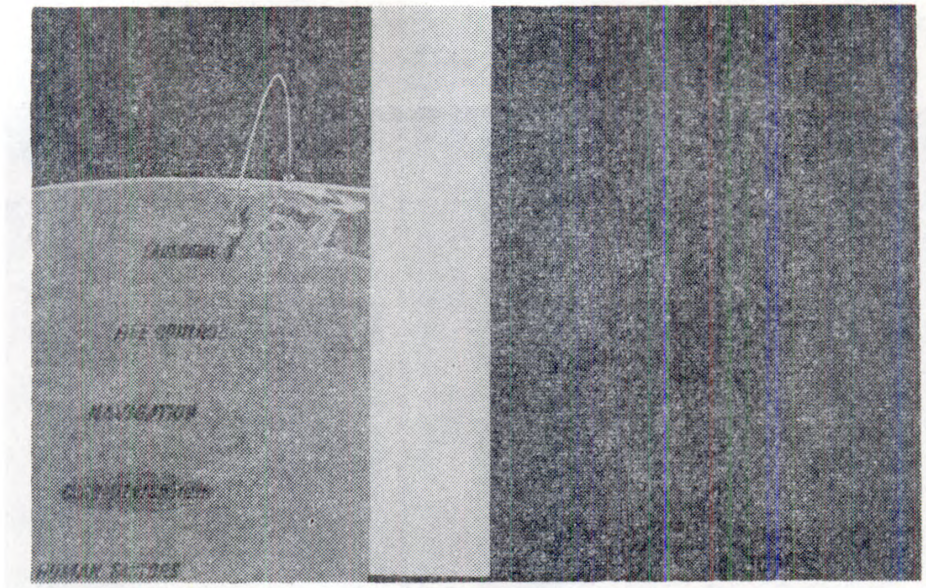

FIGURE 94

as some new ones coming along. For a period of 3 years we have been working out our problems of navigating effectively under actual conditions at sea. I can say to you, sir, without any quibbling at all that we have this problem very well in hand for our first submarines. The remarkable capabilities which we have coming along within the last 3 years has surprised all of us (fig. 95, p. 630).

Fire control, of course, is that part of the equipment in the weapons system which takes the shipborne navigation information, the position of the ship and the position of the target and ties them together in usable information for insertion into the missile guidance system. This equipment, we have some—a couple of dozen of these delivered already in various locations—actually operating the missiles where we are firing them, and they have proven out to be quite good. We are very happy with this. This is a beautiful piece of equipment and it involves some new techniques which the Navy did not know about before we started (fig. 96, p. 631).

The underwater launching has been one of our more spectacular development programs and it has come along to the point where this is no longer a problem. The success which the Navy has demonstrated in being able to launch large solid propellent ballistic missiles from below the ocean and into the air is quite marked (fig. 97, p. 631).

I am delighted, simply delighted, with this development and we have no problems here at all. We have full scale underwater test devices off of the San Clemente Island on the West Coast and there we are using the same equipment which is in the *George Washington*. We have been able to prove out under very highly controlled conditions and get really good information, scientific data. We have this equipment, of course, aboard the missile firing test ship, *Observation Island*, which has complete weapons systems equipment aboard, a duplicate of the equipment which the *George Washington* has. It has a couple of launchers aboard her and it is at Cape Canaveral now where she has already fired one very successful shot, ejecting

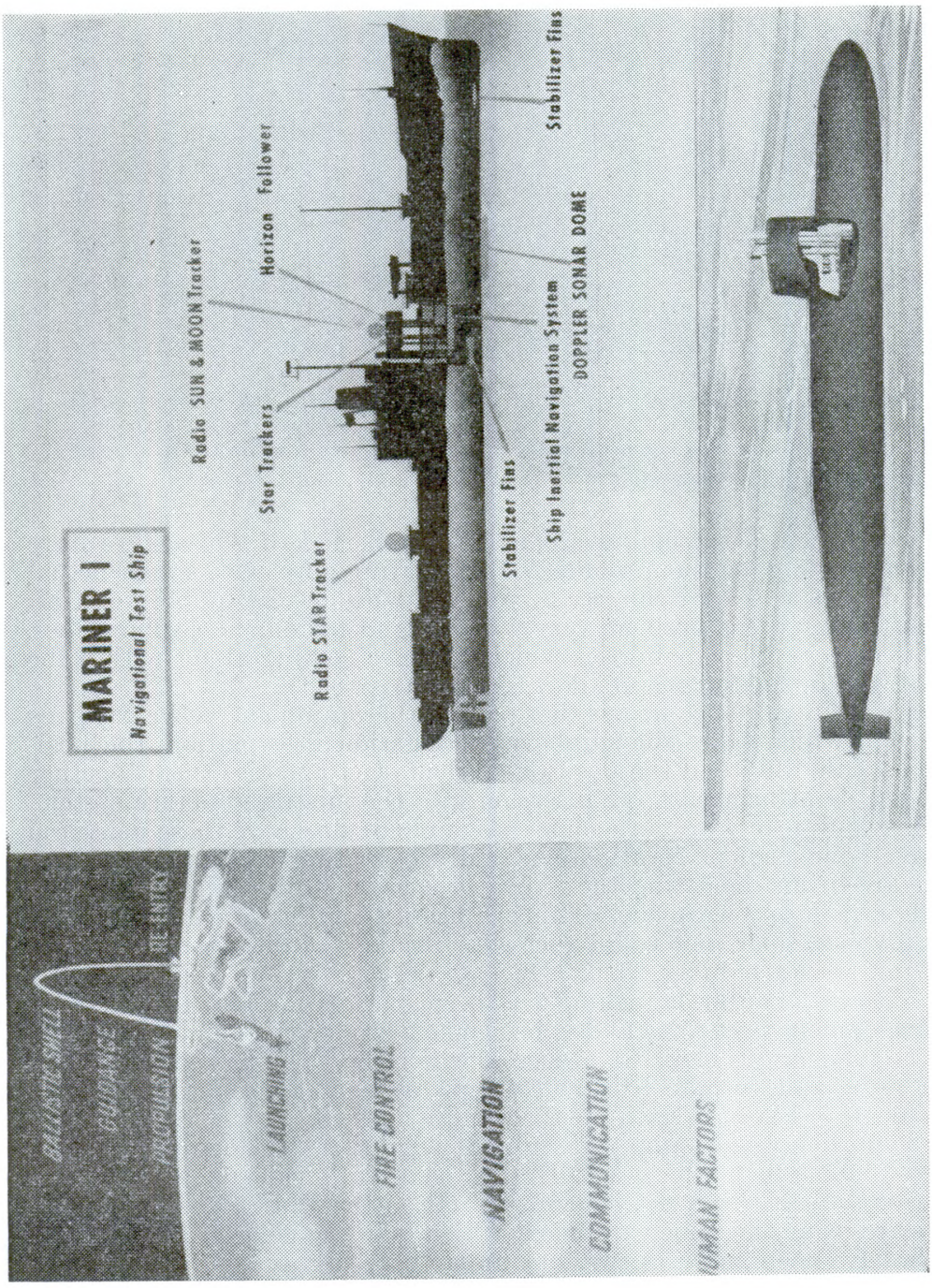
MARINER I
Navigational Test Ship
Radio SUN & MOON Tracker
Horizon Follower
Star Trackers
Radio STAR Tracker
Stabilizer Fins
Ship Inertial Navigation System
DOPPLER SONAR DOME
Stabilizer Fins
BALLISTIC SHELL
GUIDANCE
PROPULSION
RE-ENTRY
LAUNCHING
FIRE CONTROL
NAVIGATION
COMMUNICATION
HUMAN FACTORS

FIGURE 95

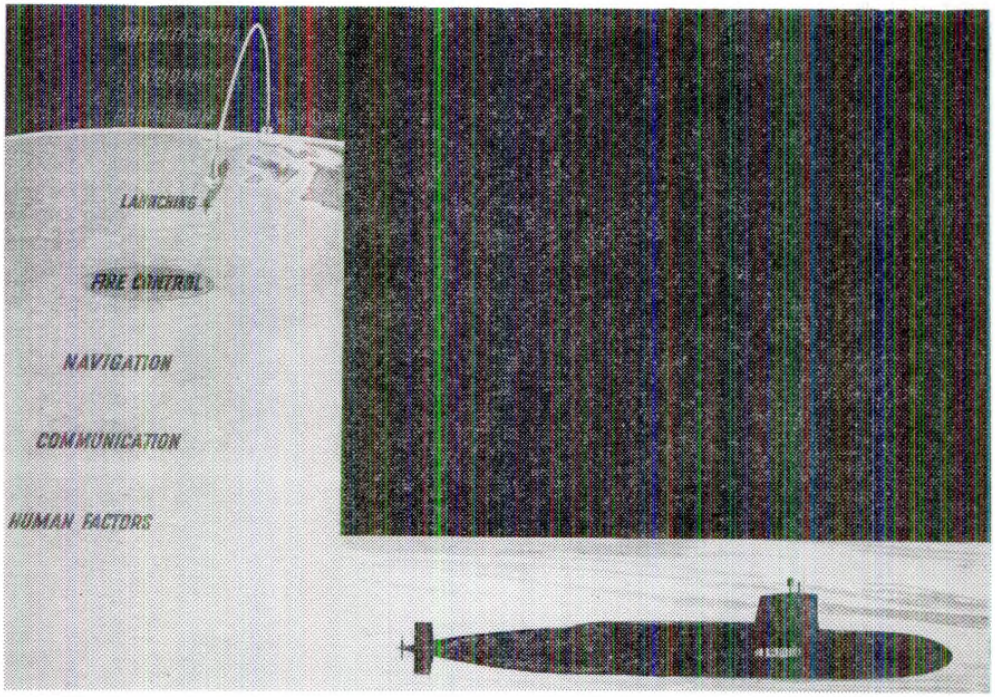

FIGURE 96

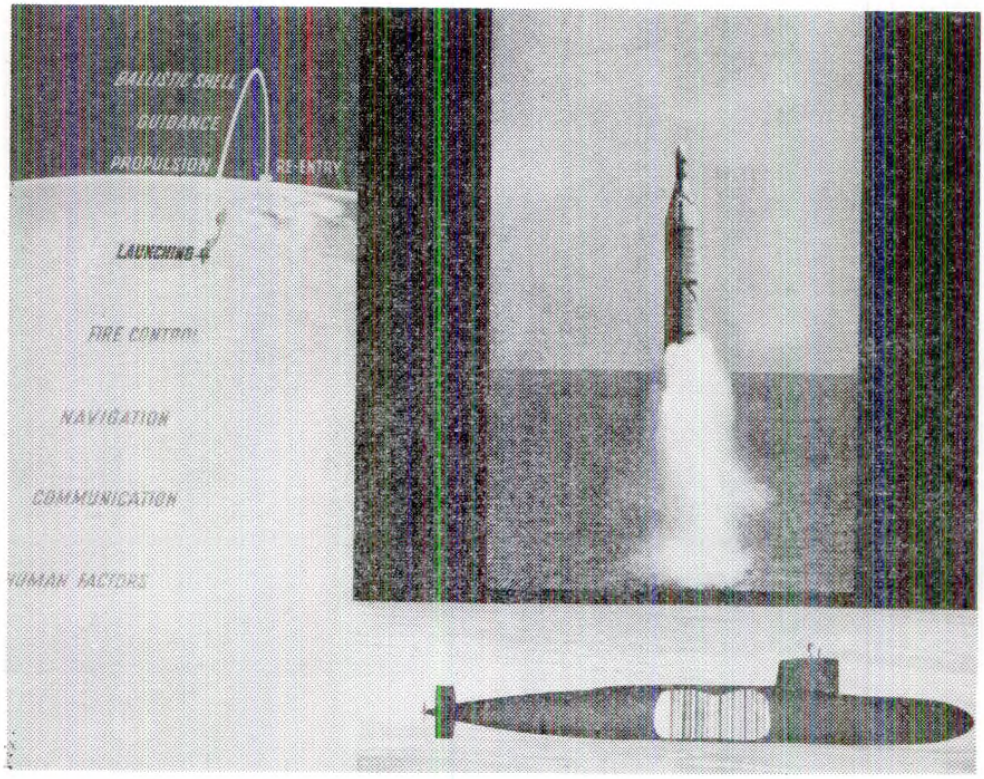

FIGURE 97

FIGURE 98

the missile into the air and off down range at wind. This shows one of our above-water launchers. This is at the Naval Shipyard in San Francisco. We get a great deal of data from this kind of a launcher. Of course, we have it below-water, as I mentioned before (fig. 98).

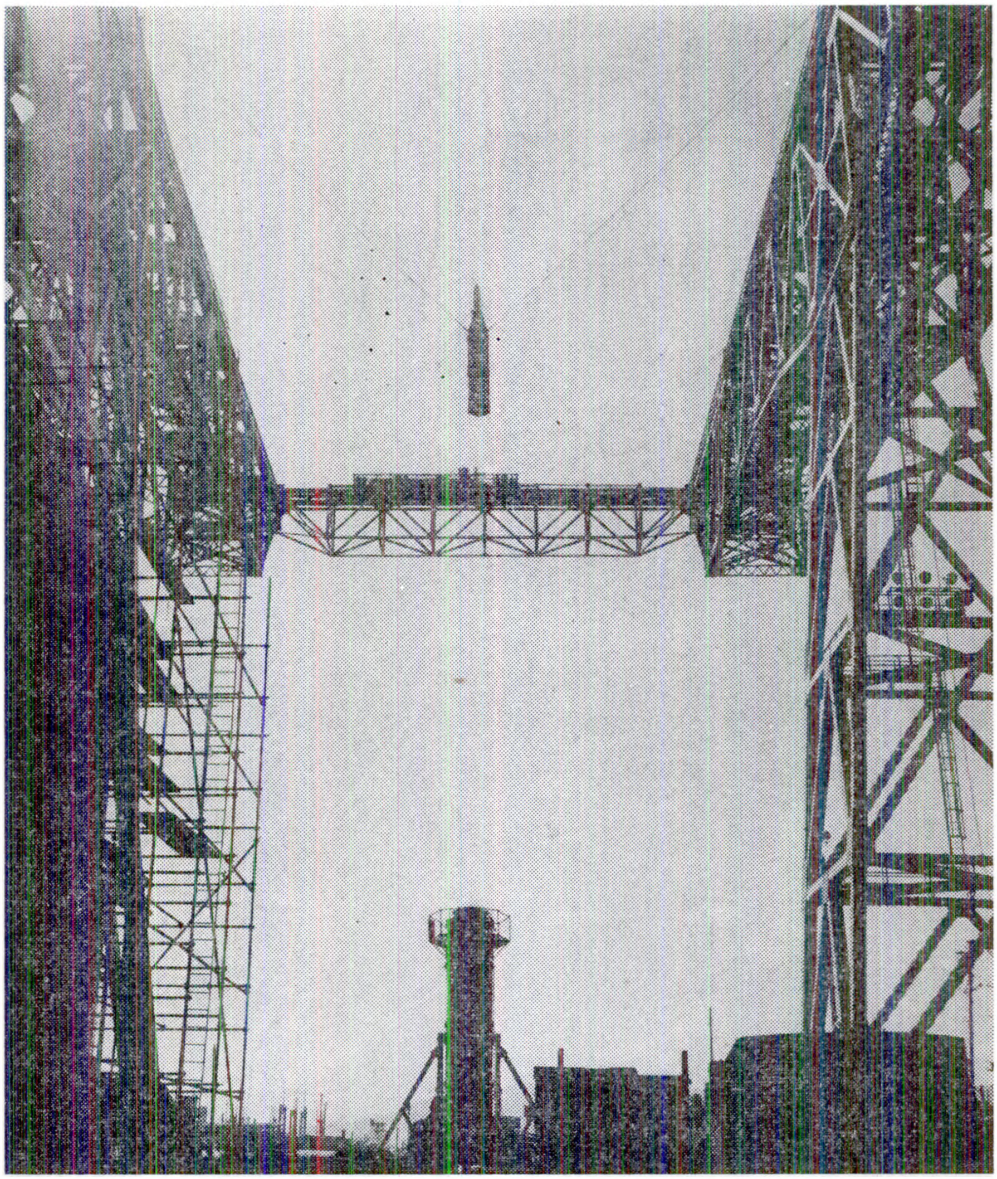

FIGURE 99

This is a cute gadget trick with which we save a great deal of dough every time we shoot one of these light-weight flight test type missiles. This building was already there. So we borrowed a spare aircraft arresting gear, put it on top of this crane and led a couple of wires down to this muscle of the above-water launcher and we fired this light-weight flight test vehicle into the air, which if we allowed to come to rest in the water would destroy itself and the expensive instruments in it. We catch it, however, in full flight up here and save about $1 million a shot. In fact, my boys save so much money here that they want to keep shooting long after—sort of false economy (fig. 99).

This is a seagoing version of the same thing. These are two steel barges, tied together catamaran fashion and this steel structure which

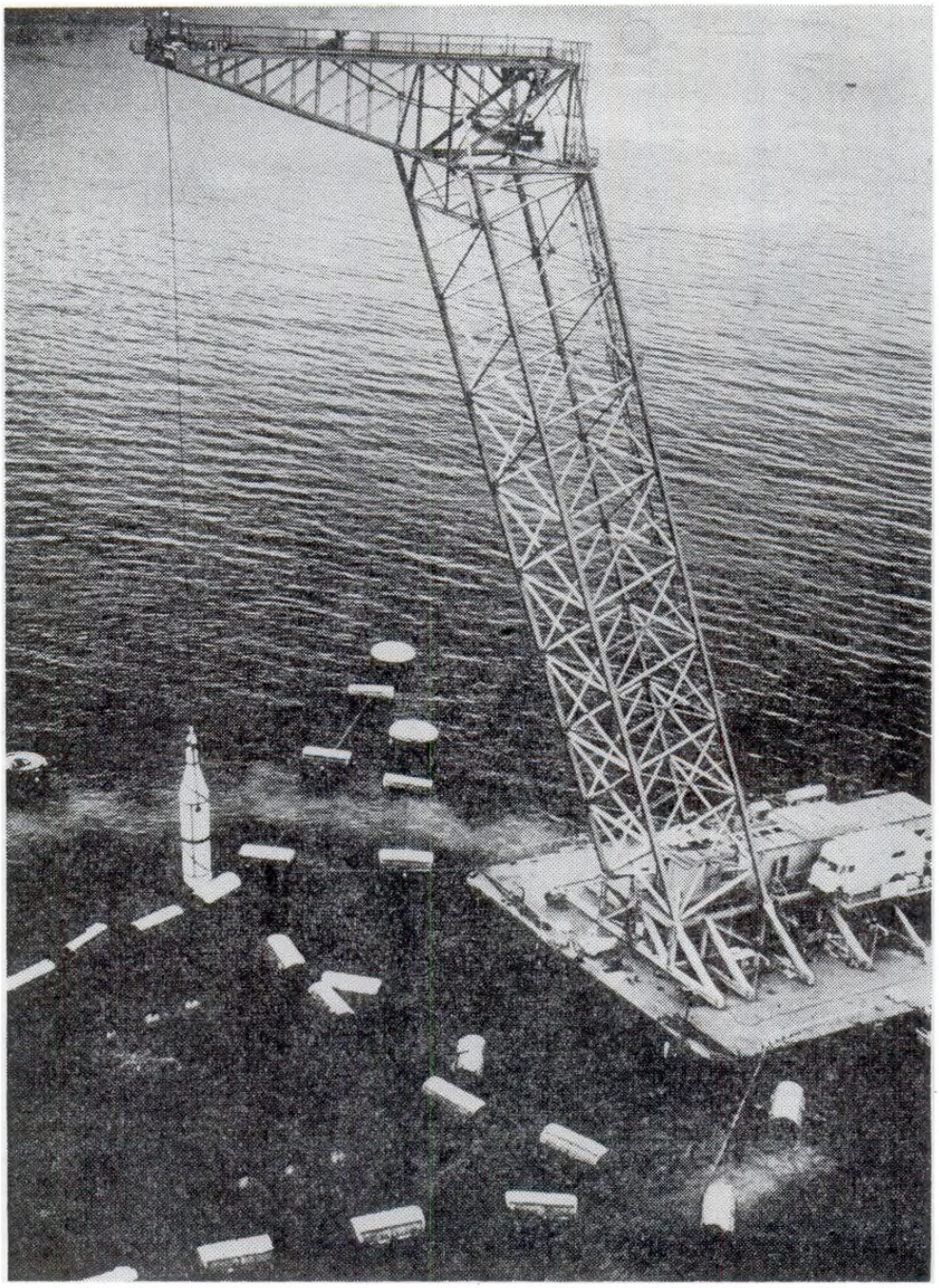

FIGURE 100

is erected on this, is about 200 feet from the top of this crane to the water. This is above the underwater launcher which is below those buoys. The missile is fired into the air and we have two engines in here, one takes the cable slack out without bothering the flight of the bird and the other catches it as it comes back. We prove it out full scale at sea (fig. 100).

Our oversized cocktail shaker or ship motion simulator has fired a couple of shots since the last time I appeared before this committee

Ship Motion Simulator

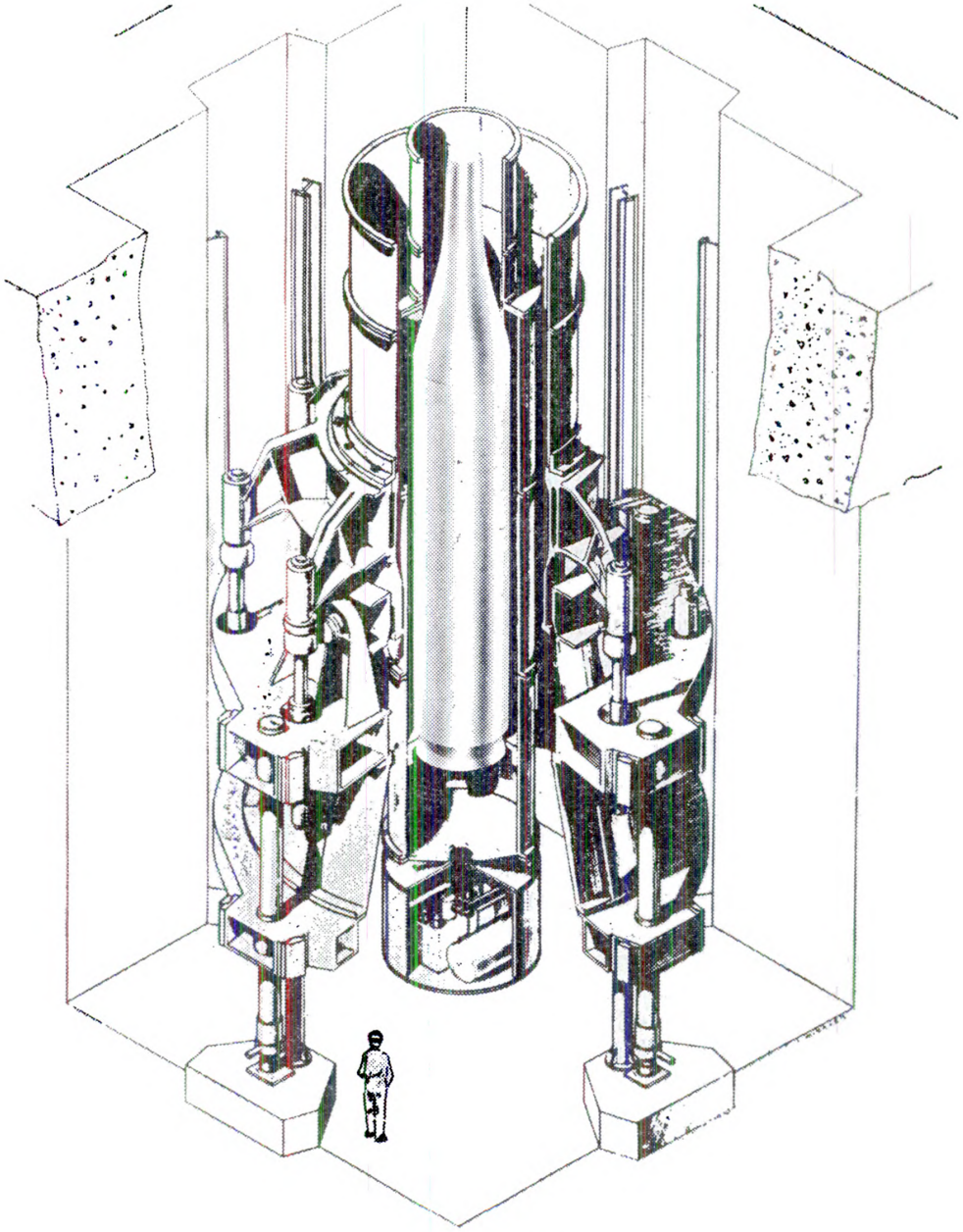

FIGURE 101

and very successfully. This is a full-scale launch of a live missile, we eject it, ignite it, and it goes off down range (fig. 101).

The next item in our development program we might talk about is propulsion. Propulsion, of course, is the development program of solid propellent motors. We have had our ups and downs in this as you would expect when you pioneer in large solid propellent missiles and were at our wits end sometimes to solve some of the problems, but we have solved them and solved them consistently and on schedule. We have a very usable solid propellent motor for this missile today.

Of course, we will improve it as we go along. It is quite safe. The Interstate Commerce Commission has granted us permission to ship this as a fire hazard and not as an explosive hazard. As a matter of fact we dropped one from 28,000 feet in an unprogramed test. [Laughter.]

And it deflagrated, it didn't detonate. A fellow asked me the other day the difference between the two, I said detonation is explosive enough to blow your pants off, but the other will leave your pants on. That was the only difference I could see (fig. 102).

The missile guidance system has done quite well. We are very proud of the way that the four full-scale flight tests which we have made since the last time I appeared before this committee have proven themselves out, with remarkable accuracy, as a matter of fact, far exceeded our expectations.

So we have this development area well in hand (fig. 103).

Ballistic shell, strangely enough is dictated primarily by the fact that it goes through the water on its way to being ignited and down toward its target. The strength of that was well proven out by an unprogramed outside loop in which we lost a jetevator on one of these first stages here and when they got up here and hit a strong crosswind it couldn't correct it, so it did an outside loop, came around and went on down range very nicely. As I say, we don't normally loop the loop, when we program it, at least (fig. 104, p. 638).

The reentry body development is in good hands. We have proven it out, the ability of this reentry body to take the heat instant to the ranges involved, it is quite satisfactory (fig. 105, p. 638).

Our record of flight test vehicles shown here can be increased by one which was last week, it was a very successful shot. We have had 51 flight test vehicles of all kinds from little fellows to built-up ones into full-scale Polaris type missiles. Thirty-five of those have been quite successful in which all of our primary objectives were achieved. Fourteen of these have been partially successful in which one or more of our primary objectives were achieved and two of those have been unsuccessful by definition although we did learn as much on the unsuccessful ones as we did on the others, as far as the development program goes (fig. 106, p. 639).

We have had remarkably good success with the latest models or batch of test vehicles; 9 out of 12 have been successful, 3 of those are partially successful, and the last 6 flights have been fully successful. We are quite proud of that. I know how a certain football coach at Oklahoma must have felt after he had 40 straight wins. We don't know how long at this stage of the game we can keep having fully successful shots (fig. 107, p. 640).

The results of our flight test milestones to date—I will read them—in December of 1956 we fired our first flight test vehicle on schedule; we shot our first proof shot of our testing-out of the principles of the launcher in July 1957; our first underwater launch was done here in March 1958; we had our first full-scale flight test vehicle of the Polaris configuration fired in September on schedule and our first live shot from the ship motion simulator at Cape Canaveral was fired successfully, as well as from the *Observation Island*, sea test, on schedule. Our first guided flight from land was done January 7 of this year and from a schedule which we set up about 2 years ago it

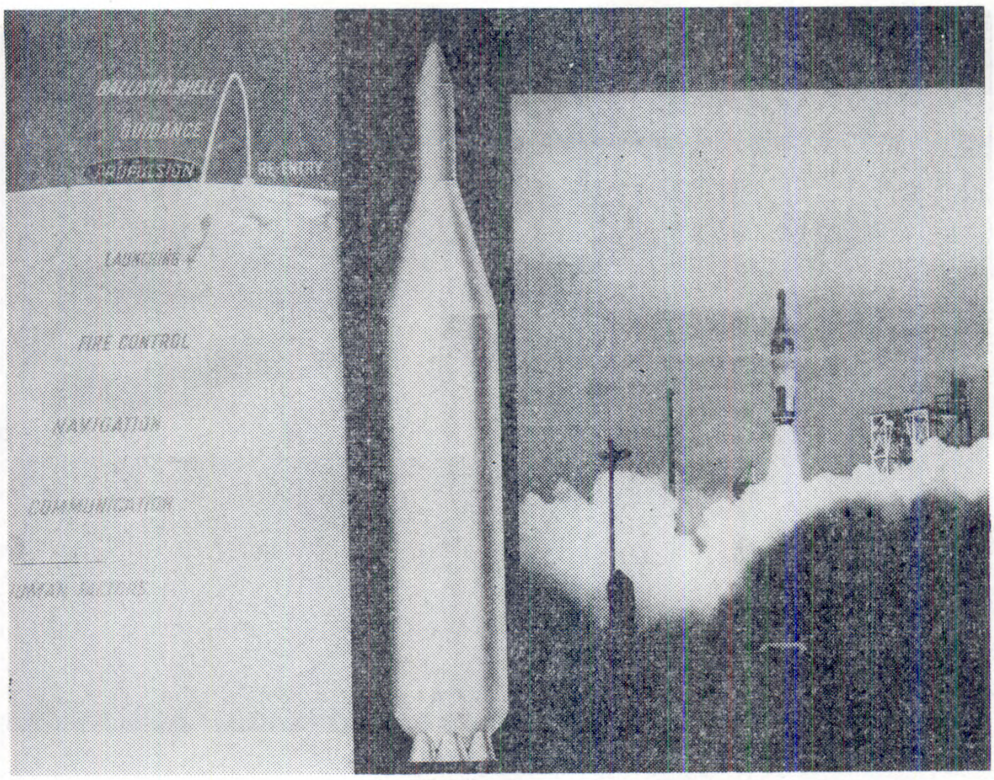

FIGURE 102

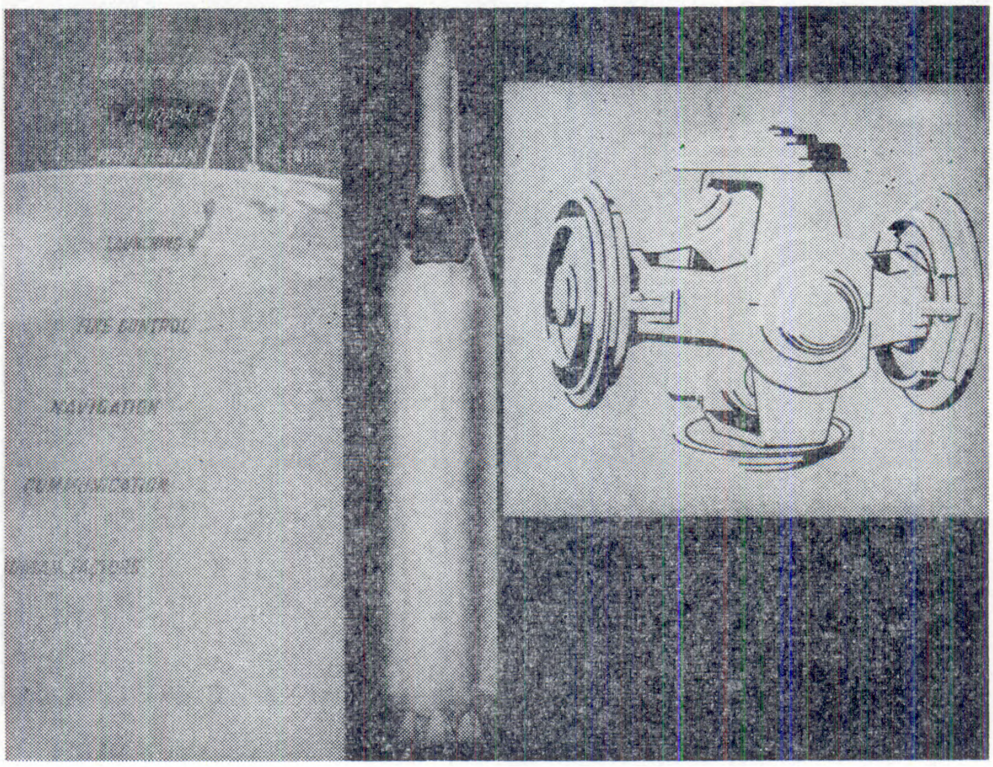

FIGURE 103

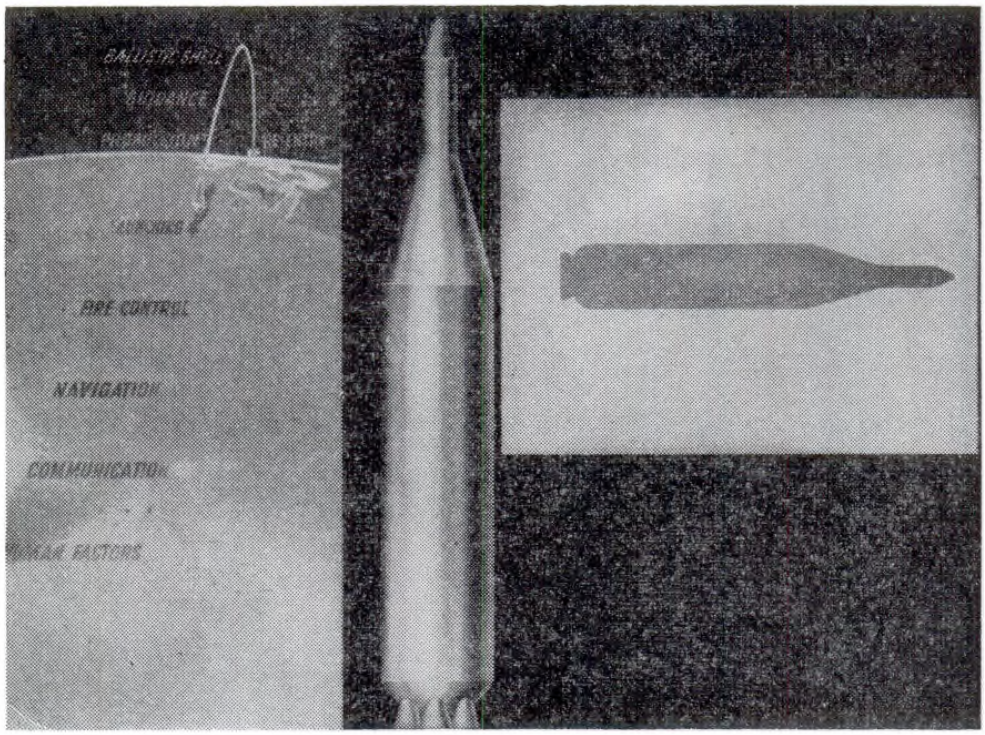

FIGURE 104

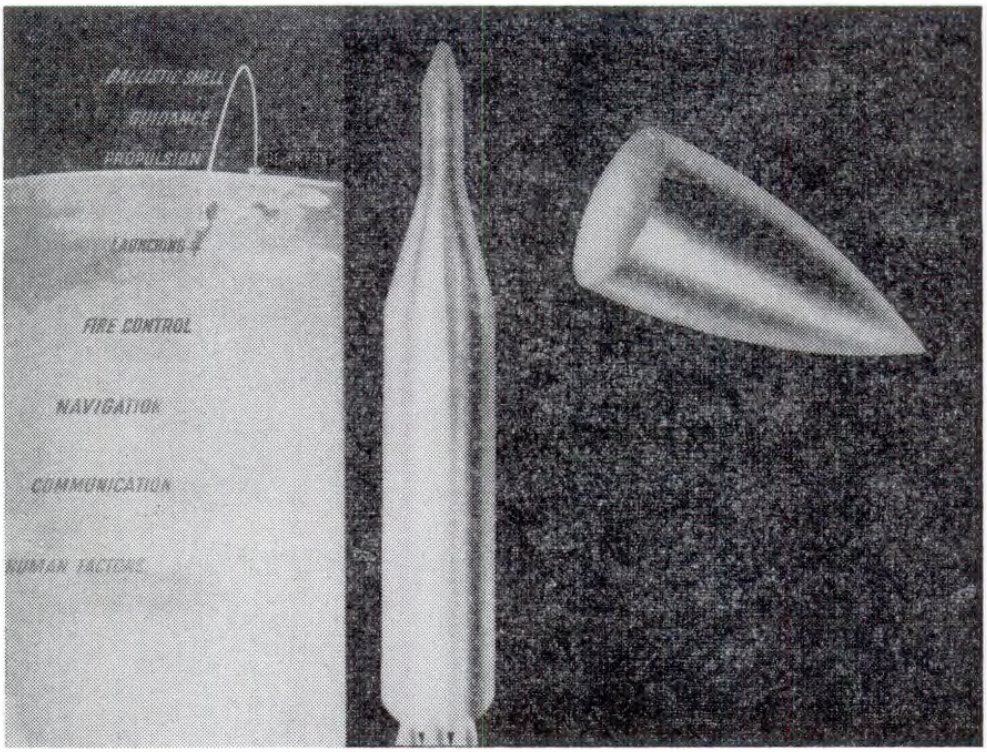

FIGURE 105

POLARIS COMPONENT DEVELOPMENT FLIGHT TEST RESULTS

35	DEMONSTRATED THRUST TERMINATION STAGE AND RE-ENTRY BODY SEPARATIONS FLIGHT CONTROL GUIDANCE COMPONENTS AND SYSTEM OPERATION SUITABLE PROPELLANT
14	PARTIALLY SUCCESSFUL
2	UNSUCCESSFUL

FIGURE 106

RESULTS OF THE POLARIS FLIGHT VEHICLE TESTS (A1X)

CONDUCTED FROM

SEPTEMBER 1959 THROUGH FEBRUARY 15, 1960

- 9 OUT OF 12 FULLY SUCCESSFUL
- 3 OUT OF 12 PARTIALLY SUCCESSFUL
- 6 OUT OF 6 FLIGHTS THIS YEAR FULLY SUCCESSFUL

FIGURE 107

was 1 week late, which I think is quite a high compliment to this developmental team that they can schedule something and meet it within a week. We have a couple of shots coming up which are rather significant, that is from the *Observation Island*, a fully guided test of all the equipment in the ship. This is a very significant test and, of course, we have an ignition from an underwater pop-up launch which will hold the hands of those folks who talk about the wet match (fig. 108, p. 642).

I think, sir, that would conclude my presentation. I have a short movie but I would prefer to show you the classified version in executive session unless you would like to see the unclassified version which I have also available.

The CHAIRMAN. Well, as between the two, it will take about the same time to see either one.

Admiral RABORN. Yes, sir. One is about 15 minutes; the other is about 10 minutes.

The CHAIRMAN. We had better see the classified version then.

Admiral RABORN. I think it would be more interesting to you.

The CHAIRMAN. All right. If there is no objection that is what we will do.

Admiral RABORN. All right. That concludes my report on the status.

The CHAIRMAN. May we ask you a question or two, Admiral?

You have a Manhattan-type program which means that you were able to get everything you needed for your program when you needed it, including the manpower and technicians and scientists and all of that. And that has given you the opportunity of staying abreast of your schedule. In fact, you are ahead of your schedule, aren't you?

Admiral RABORN. Yes, sir. We have been able to knock 3 years off the first anticipated operational date.

The CHAIRMAN. Three years?

Admiral RABORN. Yes, sir.

The CHAIRMAN. Do you attribute that to the fact that you have got the Manhattan-type organization?

Admiral RABORN. In part, sir.

The CHAIRMAN. Or do you attribute that to the superiority of the technique and the personnel?

Admiral RABORN. We would like to be modest on the second part of that, sir, but it is a well-known fact the Navy has been in the technical business a long time and we have a large reservoir of highly trained officers and civilians. Also a great deal of credit must be given to this wonderful contractual family, both civilian and military and high state of motivation of this contractual team. I think they are the best in the country.

The CHAIRMAN. Then you are satisfied with the development phase of the Polaris missile?

Admiral RABORN. Yes, sir; we are very pleased with it.

The CHAIRMAN. Actually, in the long run you are going to be short of Polaris submarines rather than missiles, aren't you?

Admiral RABORN. We are keeping them phased.

The CHAIRMAN. You are keeping them phased pretty well together?

Admiral RABORN. Yes, sir.

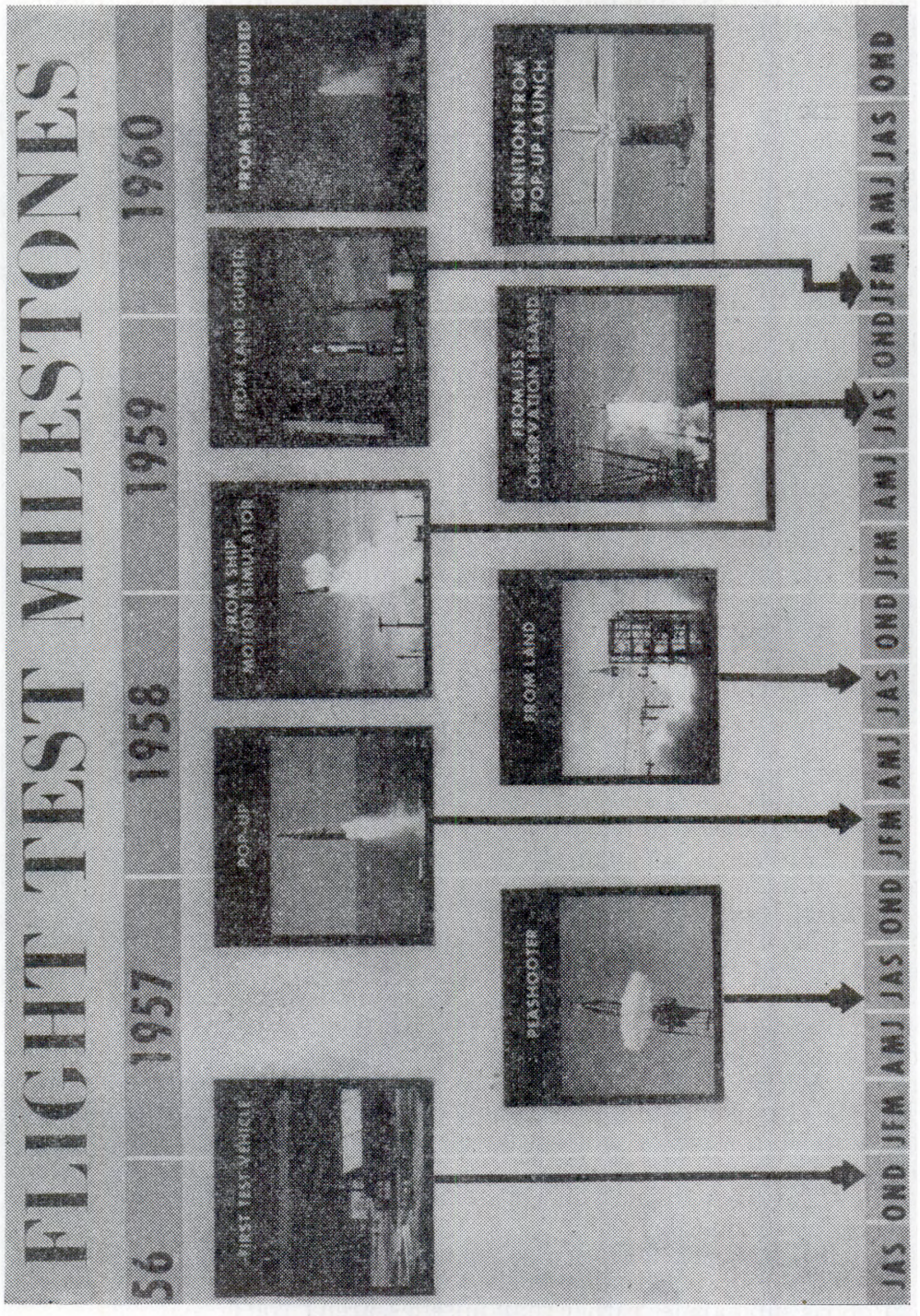
FLIGHT TEST MILESTONES
56
1957
1958
1959
1960
JAS OND JFM AMJ JAS OND JFM AMJ JAS OND JFM AMJ JAS OND JFM AMJ JAS OND
FROM LAND GUIDED
FROM SHIP GUIDED
IGNITION FROM POP-UP LAUNCH
FROM USS OBSERVATION ISLAND
FROM LAND
FROM SHIP
PARACHUTE

FIGURE 108

The CHAIRMAN. So you will have more then. When will your Polaris become operational?

Admiral RABORN. We expect to have two operational by the end of this year.

The CHAIRMAN. From then on you build right on up?

Admiral RABORN. Yes, sir.

The CHAIRMAN. As your submarines become available so will your missiles?

Admiral RABORN. Yes, sir.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. Admiral, we are glad to have you here. That is a very interesting report. You, of course, know these weapons and capabilities as well as the boats. The question is then, how many of them should we in the United States have both as to time of construction and a target date for a force that would be a maneuverable force and would be, say, the equivalent in firepower, maybe of the Strategic Air Command?

Admiral RABORN. Mr. Fulton, I believe the Navy in general and I speak only from my own knowledge and not for the Navy, particularly, believes that this weapons system will be a most welcome and is a very necessary adjunct to the mix of weapons systems for major war deterrents. We certainly don't tout this as a panacea for all major war deterrents. We believe we should have an adequate number in inventory. That number will have to be determined by an overall look, by people in much higher positions than I and with broader responsibilities.

The Navy has thought that something in the order of 45 submarines at a building schedule which is dictated, of course, by those who have broader responsibilities, would be the proper number, about the proper number to have in inventory.

Mr. FULTON. Forty-five submarine Polaris fleet for all oceans within what kind of a building period? How long would it take to reach that?

Admiral RABORN. We can get up to a very large rate.

Mr. FULTON. What is your most economical rate?

Admiral RABORN. I think from the economy point of view it is about the same as a straightforward urgent building rate, about one a month.

Mr. FULTON. And how does that compare or correlate with the present proposed rate?

Admiral RABORN. We are building three a year now, sir, and, of course, we have all been told that they want us to prove ourselves out a little bit and this, of course, is what we are trying to do.

Mr. FULTON. Then would you say that decision as to the faster building rate should be made after you prove out your Polaris, say, on target areas with a certain CEP under actual submerged conditions? How much of a test period would you have as a research and development function before you came to make the decision to go ahead on a particular model or type Polaris and sub?

Admiral RABORN. I am a very bad person to ask that because my detailed knowledge of this program and the enthusiasm which we have——

Mr. FULTON. You are the very one we want to ask.

Admiral RABORN. Makes me—well, we all wonder——

Mr. FULTON. You are an optimist?

Admiral RABORN. Yes, sir; we are optimists, that is right. When you are in this field, if you are not it is kind of bad because you get discouraged mighty quickly. But in my humble opinion which, of course, will have to be passed on by those who have broader responsibilities, we have demonstrated the necessary technical assurance that those who have the decision, if they wish to go ahead and augment the program, they could do so with confidence. That is my opinion.

Mr. FULTON. At the present time?

Admiral RABORN. Yes, sir.

Mr. FULTON. On specific impulse would you compare your Polaris with both the Atlas and the Thor?

Admiral RABORN. Well—ours is considerably less than the liquid fuel rockets but is quite adequate for our purpose.

Mr. FULTON. On size and configuration would you compare the two, say, in proportionate firepower—how big would yours be if you had it with the firepower of an Atlas or a Thor?

Admiral RABORN. Well, this, of course——

Mr. FULTON. Bigger or smaller?

Admiral RABORN. This gets into classified matters pretty fast, Mr. Fulton.

Mr. FULTON. When you compare yours—why shouldn't we make the Polaris bigger if it is capable of being handled so easily and can be stored, obviously, while these others take such a long countdown? Why don't we make yours bigger, larger and have it as a competitor of the Thor and the Atlas; or, for example, while we are thinking with imagination, cluster it and have it as a competitor of the Saturn? Is that possible? I am talking of your applications, where you might go from here. I mean when you pop up out of the water you might pop further than you think.

Admiral RABORN. Yes, sir. First let me give you a general answer as to the size. The size of the Polaris warhead is quite adequate to do the job and to increase the size of the Polaris warhead inordinately doesn't buy you a great deal. This is a very powerful warhead and one most adequate to do the job. This, of course, is all you need. You don't have to blow a squirrel's head off, for instance, to kill the squirrel, so to speak.

As for applications in other matters, clustering it and so forth. Solid propellant motors have been used for this in the past, in say, second or third stages of some of our space probes. As you know we have had clusters of solid propellant motors. I would think that those who have to do with space vehicles expertly are keeping abreast of what we are doing. Should they have a need for our type of clustered motor, Polaris type, they will certainly call on us.

Mr. FULTON. I am talking about a different thing. I am saying: What are the capabilities of Polaris technically for clustering purposes in competition, for example, with Atlas, Thor, Saturn, or Minuteman? I am saying where could you use this engine otherwise on other projects that are now very costly? Is there a possibility of such a development of the Polaris? I think people would be very interested.

Admiral Hayward, could you add to that?

Admiral HAYWARD. Well, I want to say, Mr. Fulton, I have the same confidence that Admiral Raborn has in Polaris. People question Polaris. I don't understand this for the simple reason that they seem to assume that Minuteman is here and as Polaris succeeds, Minuteman succeeds. It is tied to the same warhead technology, has a more difficult problem than we have. When you spoke about using this to replace liquid missiles, I am sure this is what Benny Schriever is doing with his Minuteman. I mean this is the solid. It is geared to the same progress that we are making in Polaris. I would comment on the number——

Mr. FULTON. So that really the Minuteman is a progression of your solid propellant through the developments that you people have already developed rather than on a liquid propellant basis?

Admiral HAYWARD. Yes, sir. The Minuteman is an outgrowth of the reaction time problem that you have with the liquids, but I feel personally, myself, from a technical point of view, that it is not an either/or situation between liquids and solids.

Liquids are storable, some of the real large warheads, quite large payloads that you want into space, it may be a liquid device. I don't think that it can be just said black or white, that you are going to go all solids. You are in about 240 pound seconds, that is the present Polaris, that is at a thousand pounds per square inch at sea level, because a lot of people quote specific impulse of 280 and 267, but this is at higher altitudes.

Roughly in the next 10 years I would say it will be up to about 257 or 260. I don't know whether Red [Admiral Raborn] agrees with this. It is roughly in that order of magnitude. So that the solid, where your present liquids are around 300 seconds, I don't think it is an either/or situation.

Mr. FULTON. My point was this, that we are doing so well on the configuration and warhead and with the solid fuel engine in the Polaris, why don't we extend the field beyond the Polaris?

Admiral HAYWARD. We are. If you mean a growth of the Polaris, certainly.

Mr. FULTON. Yes.

Admiral HAYWARD. Obviously as we go up, the range of this has gone up to 2,500 or gone on to some greater range. There is no question that this buys you a tremendous amount from the sea.

You have got 70 percent of the Earth's surface in it. So you can use and employ very effectively additional ranges and we certainly will have a follow on to the Polaris.

Mr. FULTON. So really you could get to an ICBM Polaris, couldn't you?

Admiral HAYWARD. Of course, the Navy's position is that the Polaris is an ICBM now. Our first stage is the *George Washington.* This is a very efficient first stage and we like it very much. It feeds much better than some of the other first stages, let's say. But it is an ICBM now.

Mr. FULTON. The ICBM flight range compared to your range in Polaris, there is a difference, but with the capability of the range of the *George Washington* added to an IRBM range, the Polaris, it is ICBM?

Admiral HAYWARD. Yes, sir.

Mr. FULTON. But I am talking about an ICBM flight range of the Polaris, why don't you push it up and make it an ICBM in its own right?

Admiral HAYWARD. In this year's budget we have $10 million in the research and development program just for looking at the followon to this system. The work that Admiral Raborn now is doing in specifications and warhead and all of it leads to just what you are saying.

Mr. FULTON. You need more money?

Admiral HAYWARD. I always need more money, Mr. Fulton.

Mr. FULTON. How much would you need to do that in the coming year? You see, we are interested in it.

Admiral HAYWARD. In the coming year?

Mr. FULTON. In the coming fiscal year.

Admiral HAYWARD. My feeling was that with this $10 million, if it survives all the way through, that we would be able in the 1962 budget to go forward with a pretty firm program. Now, we have to do this, of course, without interfering too much with Admiral Raborn's work right now. We don't want him to slow down on the Polaris, it is too important to the United States.

However, Admiral Raborn will have the management of this money, but we feel in 1962 we should be able to come in with a pretty good program for that.

Mr. FULTON. You would feel that $10 million is your optimum rate of expenditure?

Admiral HAYWARD. I believe so. I base this on the figures that Admiral Raborn submitted to us, really. His scientists took a good look at this program and he submitted this cost. Maybe he needs more, I don't know. He hasn't told me about it.

Mr. FULTON. This is, now, across party lines, we want you able, thoroughly, to do the job.

Admiral RABORN. I can expand on Admiral Hayward's remarks there and fill in a little bit. We, of course, are driving toward the 1,500-mile system. This, of course, will be an improvement over our first missile range. The 1,500-mile missile is an intermediate step toward whatever increase in range and performance that we would want to build into the Polaris missiles.

So we are, in effect, going pretty fast in that direction and if you look at the time scale of the Minuteman, you can see that the techniques which we are pioneering in solid propellant ballistic missiles give us a good step to make a marked improvement in the performance of the Polaris, about the same time that they expect to make theirs.

Of course, we are walking down the same path together as far as the second and third generation down the road.

Mr. FULTON. As a Navy man, I think it will probably be a submarine, first thought out by Hayward and probably produced by Admirals Raborn and/or Rickover, that will first circumnavigate the Moon from the United States.

The CHAIRMAN. Mr. McCormack.

Mr. MCCORMACK. I will pass.

The CHAIRMAN. Mr. Bass?

Mr. BASS. Mr. Chairman, I hope we can get to this movie. At the present rate we will never get through here. I would like very much to see this movie.

The CHAIRMAN. We are going into executive session at 11:30 for that purpose. Mr. Miller?

Mr. MILLER. I pass.

The CHAIRMAN. Mr. Hechler?

Mr. HECHLER. I think that everyone in this country can be justly and enthusiastically proud of the tremendous achievement of the Navy, Admiral Raborn, with respect to the Polaris development. Admiral Hayward, I would like to ask you this question very carefully so that it comes within your jurisdiction. I am impressed by the nature of the organization that has been developed in creating and producing Polaris. Now, the question I would like to ask you is whether your own personal job wouldn't be easier if this same type of organization with its attendant priority, leadership and other factors, mobilizing men and material, were, in effect, in the entire space and missile program that our country has?

Admiral HAYWARD. The difficulty is that it crosses some of the scientific, the physical sciences cross so many fields that you would be doing this for everything. Now, Polaris has a specific objective and a specific program. There are a lot of things that we do in the other programs that you would find that it would be burdened down with so many jobs that it wouldn't accomplish its purpose.

Now, I can name any number of missiles. If you did this just for all missiles, let's say, this would be a tremendous organization, a tremendous thing.

Mr. HECHLER. I was impressed by the testimony you gave a year ago before this committee which would seem to point toward that goal.

Admiral HAYWARD. When I testified, I testified on the national space exploration program and I still think a national space exploration program makes sense.

Mr. HECHLER. A single one?

Admiral HAYWARD. Yes, a national space exploration, you see. This is a specific program.

Mr. HECHLER. And you don't think we have that now?

Admiral HAYWARD. Well, under the present bill we don't. The proposed legislation for the first time talks about a national space exploration program. There are not going to be many trips to Venus or the Moon or things like that, so you are going to have to have one program set up like Polaris for it.

Mr. HECHLER. Admiral Raborn, I would like to ask you if you could relate some of the lead time involved in Polaris development with comparable development of other missiles?

In other words, do you feel that we can get this job done much faster, were more emphasis put on the Polaris program?

Admiral RABORN. I think principally it is dependent upon the lead time of long lead components. For instance, the reactors for our nuclear-powered submarines which are the same which we use in our killer submarines—they use the same type of engines and so forth—there is about a 46-month lead time to buy, manufacture, install and check out the nuclear engine room.

Mr. HECHLER. What I am trying to do is open up for you an opportunity to demonstrate why we should put more emphasis on Polaris in our national defense. As I understand, you have been able to get about 3 years ahead of your schedule in making Polaris operational. Now, can you add anything further that would cause us, as a Nation,

to want to emphasize this program to a greater extent than programs that are going on in other areas?

Admiral HAYWARD. I would answer that, Mr. Hechler. For instance, that is a really good subject, long lead time. If you had had the faith in Admiral Raborn in 1956 when we came and presented this program and you had gone forth with our program then, today you would begin—this particular year you would begin producing these submarines at the rate of one a month, and there would be no argument by anybody then that you didn't have the power or that there was any so-called gap, whether it is missile or deterrent or anything, because they would be coming off the line.

Those are the hard decisions that have to be made. Each year as we go along, they say, well maybe it will work and maybe it won't. This is the lead time. It is not the technical lead time. Because if you had made the decision then, the 46 months would have gone by, you would have had the long lead components, your system would have gone in high gear.

Mr. MCCORMACK. Will the gentleman yield right there?

Mr. HECHLER. Yes.

Mr. MCCORMACK. You mean if the decision had been made then?

Mr. HECHLER. Yes.

Mr. MCCORMACK. You understand the decision is not just purely congressional?

Admiral HAYWARD. No, it is not purely congressional. If the decision had been made then that the United States required a mobile deterrent force of this nature and that you were going to fund it and build it at a rapid rate, you would have those coming out this year at one a month.

Mr. MCCORMACK. As a matter of fact, several of the Polarises have been on the congressional level.

Admiral HAYWARD. Yes, sir, more of them have been added by Congress.

Mr. MCCORMACK. I say that with pride for all Members, without regard to party. My question is not——

Admiral HAYWARD. That is right.

Mr. MCCORMACK. Congress has apparently seen the value of this and has had the vision and the courage to go ahead making appropriations over and above the budget. Is that right?

Admiral HAYWARD. Yes, sir, Mr. McCormack.

Mr. MCCORMACK. Yes. Thank you.

The CHAIRMAN. Any further questions?

Mr. HECHLER. Yes, I have one further follow-up question. Admiral, if the decision were made today on one a month production, how soon could one a month production of Polaris be achieved?

Admiral HAYWARD. If you made the decision right now, you would work up to one a month production in 1963. By the end of 1963, you would have 15 submarines—I had better not go into some of these figures, because they are classified.

Mr. HECHLER. What additional expenditure would this take in order to achieve one a month production?

Admiral HAYWARD. Well, it would take roughly in the 1960 fiscal year about $150 million and in 1961 it would take roughly about $970 million where you went into long lead procurements.

Mr. HECHLER. And you are personally convinced that from the standpoint of national security that one a month production of Polaris would be not only feasible but necessary?

Admiral HAYWARD. Personally, I am convinced that the Polaris system is the best deterrent system that we have in the world today.

Mr. HECHLER. And you would advocate one a month?

Mr. BASS. Would you yield?

Mr. HECHLER. Yes.

Mr. BASS. Just two questions. Did you or Admiral Raborn say earlier that you are still working on an improved version of a Polaris submarine?

Admiral HAYWARD. What we said was that in the 1961 program that we have research and development money looking on—looking to a follow-on system in the Polaris missile, increasing the range, increasing the warhead, you will have a lot of payoffs. Do you want to increase the range; do you want to increase the yield?

You have all manner of things that can be done in this system like any other system. It is going to change over the years; no question about it.

Admiral RABORN. May I amplify. I think I caught the substance of your question.

Mr. BASS. My question really was: Shall we rush into mass construction and production when we perhaps can produce a better version?

Admiral RABORN. You can always produce a better version downstream, if we waited 5 years from now and carry on the work of development that you have, and we plan to have a better one. This is the nature of all weapons; that we do, on an annual basis, improve the quality and performance of all weapons systems as we go along.

Now, you will recall, sir, I think the genesis of your question may have been that I said something about a 1,500-mile system. That is what we started out to build. We planned to bring that out in the calendar year 1965. This was the best when we started out that we thought we could do 4 years ago. We were stimulated and we got into this more, we were stimulated by international events and we saw that we could bring this into being in 1963, that is a 1,500-mile system.

Then, we really were asked to accelerate it and we were well along into our development program we saw we could bring an earlier system with a perfectly usable, approximately 1,200-mile range missile using the same submarine that would use the 1,500-mile missile when it came along later.

So we settled on that. We would bring into being a 1,200-mile missile this year, and this is what we are going to do. It is a perfectly usable weapon. You can hit about 97 percent of all the targets you can hit with a 1,500-mile system. So it doesn't make any sense at all to wait until you get a 1,500-mile bullet to put into this gun. As we go along we will improve the performance of the missile, the bullet, it will fit right into the same chamber, we will walk it out in range and it will allow us to use the broad Atlantic and broad Pacific as our range sites. This is a very desirable thing.

Mr. BASS. Thank you.

Mr. FULTON. I have a unanimous consent request. Mr. Ken Hechler has a minute and a half of his original time remaining, so I have moved that he be given that minute and a half.

Mr. HECHLER. I yield back the balance of my time.

Mr. MCCORMACK. I ask unanimous consent that when I am questioning we all forget the clock. Let me watch the clock.

The CHAIRMAN. Let's proceed, gentlemen.

Mr. MOELLER. One question, Admiral Raborn. It is possible, however, that these improvements can be made as the years move on. In other words, you don't have to wait until 1963 or 1965 for these additional improvements.

Admiral RABORN. That is right.

Mr. MOELLER. They are continually being made.

Admiral RABORN. Yes, sir.

Mr. MOELLER. So we can safely say today we can start the program that we will be providing one per month in "X" number of years and all this while these improvements can continue to be made.

The second question I wanted to ask was this: One of the best arguments in favor of the Polaris is the fact that it is mobile and wouldn't be so easily found by the enemy, as, for example, our stationary launch pads, et cetera. Unless this is classified, what defense have you against other submarines? Are you prepared also for this? Is this classified?

Admiral HAYWARD. We are prepared; yes, sir.

Admiral RABORN. It is classified and we are prepared.

The CHAIRMAN. Mr. King?

Mr. KING. Admiral Raborn, at 1,200-mile range, how many of the Russian so-called vital areas could be covered?

Admiral RABORN. I would like to reserve this for executive session if I may, Mr. King. It is a very good question, and I dearly love to answer it.

Mr. KING. Let's remember to bring that up in executive session.

Admiral RABORN. I will recall it. It is sufficient to say right here that it is quite an adequate range.

Mr. KING. Glad to hear that. Continuing, I had one or two other quickies. You mentioned in your prepared statement that the human factors become a substantial limitation on the program or something like that. You didn't amplify the idea. I am sure you know what I am talking about.

Could you expand that just a little?

Admiral RABORN. Yes, sir. We recognize that the endurance of a nuclear-powered submarine is—well it exceeds the nominal alert human response or behavior. So we have two crews in these submarines and we will spell them off one after another, just as you do when you have people on watch in various parts of the ship, we will change the whole crew. Thus, we will keep one crew out there, we hope, in a very alert frame of mind and also keep the high enlistment rate up.

Mr. KING. What is the maximum time of alertness that you have worked out?

Admiral RABORN. This is dependent upon, of course—and that is classified, the exact amount, sir, and I will give that in executive session—but it is dependent on the type of motivation you give the crew, the habitability of the submarine, the way in which they are held by their fellow countrymen. Are we proud of them? It is that sort of a thing.

Mr. KING. You did state, I believe, that generally the morale and motivation was very high?

Admiral RABORN. Yes, sir.

Mr. KING. This Manhattan-type organization, could you give us just a little background of that?

Admiral RABORN. Well, I would like to because it has been very pleasant to have one. I report directly to the Secretary of the Navy and I have two pieces of paper, one from Admiral Burke and one from the Secretary saying if you have difficulty with anybody bring them to see me. Fortunately we have had no difficulty. The response of the Navy as a whole has been tremendous. I think it is highly complimentary to the Navy's organization that they could take a Manhattan-type organization, operating within it and support it on a wholehearted basis without disrupting, if you please, the nominal business of the Navy.

Mr. KING. What are the characteristics of that type of organization?

Admiral RABORN. The characteristics are that I have a job to do and I have a minimum of bosses and I have top priority and I can go into any man's organization in the Navy, and commercial organizations too, with the Presidential No. 1 priority, and get a job done or equipment or things accomplished on a first-call basis. And this is what is meant.

Admiral HAYWARD. Maybe I can describe it. Admiral Raborn is the General Groves of the Navy. He has all of the appropriations involved. I am responsible for the research and development organization. He has ships and ordnance, ammunition, RDTM, military construction, it is all in his shop. He tells the people what to do, when to do it and where to do it. This is the boss, he is the boss. This is exactly why he is like General Groves. If he wants of course, I don't know in this day and age you can duplicate what General Groves did—to build three plants, but if Red wanted to do it, he could do it. So he is the boss in fact as well as in name.

Mr. MILLER. He has to make the decisions?

Admiral HAYWARD. Yes, sir; and he has the responsibility along with the authority.

Mr. MILLER. And he has exercised that, hasn't been afraid to do it?

Admiral HAYWARD. Yes, sir; he is not redheaded for nothing.

The CHAIRMAN. Mr. Roush?

Mr. ROUSH. Didn't you appear on a TV program last Saturday night?

Admiral RABORN. It was my pleasure, sir.

Mr. ROUSH. I thought I heard you say during the course of that program that the Russians did not have a submarine similar to the Polaris; is that correct?

Admiral RABORN. That is correct.

Mr. ROUSH. Is that so? They do not have a submarine similar to the Polaris?

Admiral RABORN. To the best of my knowledge.

Mr. ROUSH. I thought I had heard Admiral Burke tell us the other day, that they did have.

Admiral HAYWARD. Yes, sir, but there is a great difference.

You saw the picture of the submarine that was flushed off Iceland some months ago. It was quite obvious that those submarines, when

the Russians went about it, in a simple manner, launch from the surface. They didn't believe a submarine was vulnerable on the surface as much as some of our people did. So they don't have a submarine like the Polaris. They don't have the nuclear submarines.

Mr. ROUSH. I don't believe Admiral Burke amplified his testimony the other day, but I do recall him saying that there was one similar and it had a range of 350 miles.

Admiral HAYWARD. He probably didn't enlarge the fact that it was a surface launch device, launched right from the surface of the sea, didn't do it submerged.

Mr. MILLER. Will the gentleman yield?

Mr. ROUSH. Yes.

Mr. MILLER. We have had the Regulus for quite some time and it was surface launched from submarines and its range was over 300 miles, wasn't it?

Admiral HAYWARD. That is correct.

Mr. MILLER. And we have abandoned that as being a bit obsolete and obsolescent, haven't we?

Admiral HOWARD. Yes. We haven't abandoned it. These submarines are actually deployed and on station now.

Mr. MILLER. I know, but we are not building any more.

Admiral HAYWARD. No, sir; we went to Polarises.

Mr. MILLER. And that is comparable in efficiency to this Russian submarine?

Admiral HAYWARD. Yes, because with a conventional submarine like those equipped with Regulus you have to come up anyway.

Mr. MILLER. That is true.

Admiral HAYWARD. So the Russians think very simply, Mr. Miller, and this was a simple approach to the problem and a good one from their point of view to utilize that particular class which they had.

Mr. ROUSH. Is Project Transit tied to the Polaris submarine in any way, Admiral?

Admiral RABORN. I can answer that more fully in executive session, sir. It is not a matter under my direct control and I have direct control of all navigational matters which are of immediate significance to me.

The CHAIRMAN. Mr. McCormack?

Mr. MCCORMACK. How many Polarises have been built now, for the record?

Admiral RABORN. Submarines, sir?

Mr. MCCORMACK. Yes.

Admiral HAYWARD. There are nine authorized and building, plus two tenders and actually one is commissioned——

Admiral RABORN. We have four in the water, one of which is commissioned.

Mr. MCCORMACK. And how many in the coming budget for the next fiscal year?

Admiral RABORN. Three and long-leadtime items for three more in 1962.

Mr. MCCORMACK. I notice you use the words:

The Polaris fleet ballistic missile will initially have a range of about 1,200 nautical miles with a capability of carrying a powerful warhead.

Will you tell me what you mean by the word "initially"?

Admiral RABORN. Well, when we were asked to cut 3 years off our already accelerated program, we felt that the state of development of the solid propellent missile would be such that we could get a missile with a range of about 1,200 miles and that is what we then will have.

Mr. MCCORMACK. In other words——

Admiral RABORN. But we are going ahead with the main drive toward a 1,500-mile system?

Mr. MCCORMACK. In other words, at one time the objective was 1,500?

Admiral RABORN. It still is, but we are doing a takeoff of the mainstream development.

Mr. MCCORMACK. I think either Mr. Bass' or Mr. Moeller's questions in that respect clarify it, but that word, "initially," that interests me like the word "overall." That is all.

The CHAIRMAN. Any further questions?

Mr. MCCORMACK. No.

Mr. SISK. No questions, Mr. Chairman.

The CHAIRMAN. Now, then, Admiral Connolly, do you care to—as I understand it, you want your statement in the record. Do you care to amplify it in open session?

Admiral CONNOLLY. That is right, Mr. Chairman, I would like it to go in the record.

The CHAIRMAN. If there is no objection, we will place the statement of Admiral Raborn and Rear Admiral Connolly in the record as presented to us.

Admiral CONNOLLY. Thank you, sir.

(The statements above referred to are as follows:)

STATEMENT OF REAR ADM. W. F. RABORN

Mr. Chairman and members of the committee, I welcome this opportunity to give you another accounting of the status of the fleet ballistic missile weapon system, generally known as Polaris. The continuing interest of your committee in the fleet ballistic missile program and concern as to its status is very constructive and healthy.

Late this year, calendar year 1960, the fleet ballistic missile weapon system is planned to be operational and should provide the United States with a unique, mobile, and global weapon system. Delivery of the first operational ballistic missiles and the self-sustaining nuclear-powered submarine is being accomplished in unprecedented time—in fact, as I told you last July, almost 3 years earlier than believed possible when the fleet ballistic missile program was announced in January 1957.

Before telling you in detail where we stand today in our Polaris missile development program, I believe it would be worth while to describe briefly the fleet ballistic missile program and our past efforts—the road over which we have traveled to date and the speed limits observed.

The fleet ballistic missile weapon system occupies an extremely important position in the current and future military posture of the United States, and complements other deterrent forces in being or under development. It is designed to give this country a new military capability—the capability to launch long-range ballistic missiles with powerful warheads from nuclear submarines. The combination of the missile, the submarine with its launching and handling, fire control, and ship's navigation devices, plus specially trained submarine crews constitute the powerful sea element of the fleet ballistic missile weapon system.

In the fall of 1955, the President approved a project to develop a ballistic missile system with consideration to be given to both land basing and sea basing. The Navy created the Special Projects Office and as director, I was charged with the responsibility for technical direction and management of the FBM weapon system development, or more specifically, to engineer the sea application of the Jupiter missile.

For a year, we worked hand-in-hand with the Army, whose job was to develop the Jupiter missile. This was indeed a most harmonious partnership and the Navy gained invaluable technical experience.

Since liquid fuels presented virtually insurmountable problems for shipboard use due to safety, space and launching factors, investigations were soon directed toward the development of a solid propelled missile. Meanwhile, significant advances in solid propellent and warhead research occurred. The state of art of long-range, long-endurance nuclear submarines was also well advanced.

In late fall of 1956, the Navy proposed and was authorized to pursue independently the present FBM system with the solid propellent Polaris coupled to the nuclear submarine. In March 1957, after 3 months of continuous study by an industry-scientist-Navy steering group, the weapon system parameters were established. These parameters were based on the most advanced concepts in state of art and the best technical judgments of attainable improvements within the next decade.

These basic parameters and concepts, aside from minor exceptions, have not been changed after 3 years of effort. New technological advances are being incorporated into production components as they occur and at minimum cost. Growth potential is a built-in feature of the system. The nuclear submarine, the major capital investment in the weapon, had a life of at least 15 years.

Let me tell you briefly what the FBM system in operation will offer to our country. A basic requirement of any missile is that it must be able to reach, with accuracy and effectiveness, most of the important potential targets in the world. The Polaris fleet ballistic missile will initially have an operational range of about 1,200 nautical miles and the capability of carrying a powerful warhead. With this range missile, Polaris is in effect a global military weapon in that in excess of 90 percent of the Earth's surface can be brought within striking distance of this mobile system operating from concealed ocean depths. The FBM submarine will be able to navigate accurately, whether surfaced or submerged, using conventional and greatly advanced navigation devices and techniques. At all times, the FBM submarine will know her location in relation to planned objectives and, thus, the missile can be accurately targeted.

Launching points of the weapon system will be constantly moving about so that they cannot be pinpointed in advance by an enemy. The Polaris weapon system is virtually immune to surprise attack and invulnerable to enemy long range missiles because it possesses real mobility. This is fundamental, the ability to operate from one concealed area now and from another hidden area somewhere else one hour later.

As the *Nautilus* and her sister ships have demonstrated the highly mobile, nuclear submarines can remain submerged for extended periods of time, either relatively stationary or cruising over vast ocean areas.

Any retaliatory system to have maximum effectiveness must possess fast reaction time. The solid-fueled Polaris missile will always be ready for firing without protracted delays for preparation. This is characteristically true of missiles with solid propellants.

Polaris deployed in submarines, unobstrusively cruising the oceans removes these weapons from inhabited areas to the seas. It poses an insurmountable intelligence problem to the enemy since every unidentified submarine is a potential Polaris launcher.

Thus, the enemy's countermeasure problems and problems of defense are compounded and complicated. The system presents to any potential aggressor an unquestioned and continuing capability, one which can be comprehended and appreciated.

Because of the threat of deliberate and inevitable retaliation from these concealed mobile launching platforms, the Polaris system should prove a powerful deterrent to any potential aggressor from striking the first blow. With this system, the United States will have a unique global military capability which complements our other retaliatory weapon systems, and which will be under the control of the United States.

Development of this global military capability has been most rapid. In January 1958, the Navy announced an accelerated development schedule with the 1960 target date for initial operational availability. At that time, we were well ahead of schedule and could confidently proceed at a stepped-up pace. Essentially, it was recognized that to meet the accelerated and augmented schedule we would have to resort to all possible means of expediting the work, through shortcuts, and maximum but sensible use of overtime.

Multishift operations and extended workweeks for specified periods were authorized for various shops at contractors' plants to assure that components of the subsystems were all available to dovetail into a fully operable system when needed.

The centralization of responsibility for all aspects of the program under the Special Projects Office as the single weapons system manager, unquestionably facilitated the development effort. With surety, the component parts of the development program have been managed and monitored in unison to meet our operational goals. This includes, in addition to the weapon system itself, the related elements such as production and operational support. The industrial base, logistic facilities and skills essential to support an expanded FBM force have largely been established. The industrial capacity is that necessary to support the presently authorized force, but is also an excellent base on which to build as desired.

The Polaris ballistic missile is a relatively small, compact, solid-fueled missile. A small but highly accurate guidance system had to be developed and simultaneously, made compatible with the missile and the shipboard fire control system. The reentry body represents advanced technology. We have led the way in the harnessing and control of solid propellent motors, use of jetevators for missile flight path control, and means of precise thrust termination to impact on target. We must, of course, continue our development tests to attain the required degree of reliability and to achieve our ultimate system as contrasted with our initial operational objectives. Production of components for the tactical missile is proceeding satisfactorily.

Our flight test program has continued with very gratifying results. Through February 10, 1960, out of a total of 51 flight tests of various types, our technical staff and advisers have rated 35 completely successful since all specific technical test objectives were achieved. These fully successful flight tests included launchings of two-stage solid fuel test vehicles in August 1959 from a shore-based ship motion simulator and at sea from the U.S.S. *Observation Island*, the FBM weapon system test ship. The first fully guided flight was conducted with excellent accuracy on January 7, 1960. Fourteen of the fifty-one flight tests were rated partial successes in that one or more of the primary technical objectives were met; two were failures.

In other words, since I appeared before you last July, we have had 18 flight tests and the score is 11 fully successful flight tests; 7 partially successful. Twelve of the flight test vehicles fired in recent months are more fully representative of the tactical missile. On these our record is 9 out of the 12 fully successful with 3 partially successful.

What this means is that the solutions we devised and corroborated through our ground test program in the fall of 1959 to correct certain deficiencies brought to light through tests in a flight environment are proving to be adequate. As we move more rapidly into the advanced testing stages we may encounter new problems but with our experience backlog, I sincerely believe that as they occur they will be temporary and susceptible to immediate correction by our competent team. We are on schedule, and in a number of cases, ahead of the development challenge established 3 years ago.

The missile flight test program is the most spectacular of all the Polaris system tests. Our approach has enabled us to take advantage of partial successes and failures in ground tests and in flight to arrive at a complete understanding of unanticipated phenomena, and to utilize our successes in flight to make tremendous strides in proving features of the tactical missiles. Let me review briefly the 12 advanced development model flight tests conducted since last July. In September 1959 we fired the first of these from the flat pad at Atlantic Missile Range and performance was almost identical to that specified in the specific technical objectives. The reentry phase of the flight was highly successful.

In October, we fired the second vehicle but the flight was terminated shortly after the second stage motor ignited due to difficulties in the motor. The third vehicle was flown successfully in November, again with excellent reentry body performance. During December, we conducted three additional flight tests. In each instance, the vehicles were launched perfectly, and one performed exactly as predicted. In one case, first stage powered flight through first separation was good until the igniter adapter malfunctioned (a random type failure), and suddenly terminated flight. In another case the vehicle veered off course and the Range Safety Officer destroyed it.

In January we have had four fully successful tests. On January 7, 1960, we conducted our first fully guided flight test. Performance of the guidance system was outstanding. May I state that the guidance system, in every preceding ground test and as a passenger in several of the flight test vehicles, has operated successfully. In this test, utilization of our radically new fire control system was made and similar fire control systems are being installed in the FBM submarines. Satisfactory performance provides another degree of confidence that our integrated weapon system will have the required accuracy. The other full-scale flight test vehicles successfully flown in January and on February 4 and 10 provided further assurance of guidance operation and accuracy, reentry body design, and integrity of the missile as a whole.

Remarkable progress continues to be made in our launcher development program. Last July I showed you pictures of the ingenious devices used to prove out the feasibility of underwater launching and the compatibility of the missile and launching tube. At San Francisco Naval Shipyard, we have Operation Skycatch and Peashooter, dry land launching facilities to test various methods of ejecting the missile from the tube. At San Clemente Island, Calif., Operation Pop-Up and Fishhook have repeatedly demonstrated the feasibility of underwater launching of full-size missiles, and of stable travel of test vehicles through and out of both calm and turbulent water. Skycatch and Fishhook are devices with the capability of arresting the test vehicle in midair which means the vehicle can be reused time and again. Tests at the two launcher facilities will continue to pioneer further developments in launching methods and devices.

All aspects of the FBM ship construction have progressed satisfactorily under the accelerated schedule. Four FBM submarines were launched during 1959; the USS *George Washington* at Groton, Conn., on June 9; USS *Patrick Henry* at Groton, Conn., on September 22; USS *Theodore Roosevelt* at Mare Island, Calif., on October 3; and the USS *Robert E. Lee* at Newport News, Va., on December 18. The USS *George Washington* was commissioned on December 30. With a Navy crew in charge, the USS *George Washington* is now undergoing an extensive installation test program and other required tests and trials preliminary to the first live missile firing later this year. The program of dummy missile shots from the ship was successfully completed prior to December 30, 1959.

The USS *Observation Island*, the FBM weapon system test ship, has recently been equipped with additional prototype equipments, and will shortly resume operations at sea.

A submarine tender is being converted to provide afloat maintenance for the FBM submarines and will be available for service in late 1960. A second tender new construction, is in initial stages of construction.

Important shore facilities, which are an integral part of the FBM program include the Missile Assembly facility at the Naval Weapons Annex, Charleston, S.C., and a team trainer at the submarine base, New London, Conn. These facilities will be fully operational when needed to support the FBM operational capability. Of course, we have had to supplement the facilities at the Naval Test Complex at Cape Canaveral, Fla., to accommodate the progressively advanced Polaris experimental test vehicles.

Additionally, port facilities have been provided at Cape Canaveral to support the FBM ships prior to conduct of shipboard missile firings down the Atlantic Missile Range.

The FBM program is being developed and managed as a complete program package under authority delegated to the Special Projects Office. The program from its inception has been reviewed and approved in total terms which permit completely integrated and balanced planning and administration by the director and his departmental staff of less than 250 military and civilians. As part of our approach to the development of the FBM weapon system in the spring of 1957, we spent considerable time in planning and scheduling our program. The Special Projects Office devised a management system with the following objectives: to organize facts for complete decisions and staff actions, to provide a basis for accountability of performance on approved projects and a "need-to-know" reporting system and to provide a framework for responsible and objective evaluation of progress. We explored and developed new management techniques, including a system generally known as PERT (Program Evaluation and Research Technique utilizing a digital computer) which has been widely utilized in whole or in part by other services and private industry for the purpose of research and development management. These efforts have kept the

status of the FBM program known at all times, including how our funds are used. Problem areas can be readily identified before they become critical, and we have a factual basis on which to make the numerous day-to-day management decisions attendant to such a large complex program.

In summary, the FBM program has forged ahead with sophisticated developments on a very tight time schedule. An advantage has been a top priority rating, co-equal with the other major missile programs of the Department of Defense. Based upon performance to date and an intimate knowledge of the work yet to be accomplished, the Polaris submarine weapon system with its allied operational and logistical support is planned to be available operationally this year with the readiness of the USS *George Washington.* Other submarines are planned to be deployed at intervals, with a total of 9 Polaris submarine systems expected to be ready in a timely manner. Moving at will within the safety of the ocean depths, the Polaris submarine can be expected to accomplish her mission.

STATEMENT OF REAR ADM. T. F. CONNOLLY, ASSISTANT CHIEF, BUREAU OF WEAPONS, PACIFIC MISSILE RANGE AND ASTRONAUTICS, DEPARTMENT OF THE NAVY

Bureau of Naval Weapons Organization for Space

The Bureau of Naval Weapons organization for space is shown on the accompanying chart. Under the Secretary of the Navy and the Chief of Naval Operations, the Assistant Chief of the Bureau of Naval Weapons for Pacific Missile Range and Astronautics provides a specific point of contact for coordination or progress which are being conducted under the management of the Bureau and its various field activities. (Chart 1.)

Basic organizational planning for the Bureau of Naval Weapons provided for the ready adaptation and direction of weaponry in the advanced space technology field. Although the major weapons development area in the Bureau of Naval Weapons organization is under an Assistant Chief for Research, Development, Test, and Evaluation, other line operating Assistant Chiefs are assigned to areas that include contracts, production and quality control, fleet readiness, and field support. Included in the Staff Assistant Chiefs is the Assistant Chief for Program Management to whose office the Assistant Chief for Pacific Missile Range and Astronautics is attached.

The Assistant Chief for Program Management, in addition to being placed in staff capacity to the Chief, also participates in a verticality of reporting lines involving the line Assistant Chiefs, including that for Research, Development, Test, and Evaluation, where management of major bureau programs is the order of business.

In weapons development and procurement, the Assistant Chief for Program Management essentially outlines what is to be accomplished, along with timing guidelines. He is responsible to the Chief of the Bureau of Naval Weapons for planning and executive direction of all Bureau programs, including the assignment of resources for their accomplishment. It is then the responsibility of other line Assistant Chiefs to perform timely development and production, furnish progress reports, and work out program changes and modifications of requirements or objectives.

Such a basic organizational pattern was devised as the best possible approach to workable management of the activity which would give functional grouping of skills and knowledges pertinent to research and development, materials management, and field support; to provide maximum vertical management with flexibility to meet shifting technological and business emphasis; to provide feedbacks enabling program reviews; and to keep at a minimum the numbers of people reporting to the Chief, Bureau of Naval Weapons.

Also attached to the Assistant Chief for Program Management are two Assistant Chiefs within this organization, the Assistant Chief for the Pacific Missile Range and Astronautics, and the Assistant Chief for Program and Management Plans.

The Assistant Chief for Pacific Missile Range (PMR) and Astronautics programs is responsible within the organization of Assistant Chief for Program Management for overall coordination, policy, and executive direction and administration of all plans and programs within the Pacific Missile Range and

BUREAU OF NAVAL WEAPONS ORGANIZATION FOR SPACE

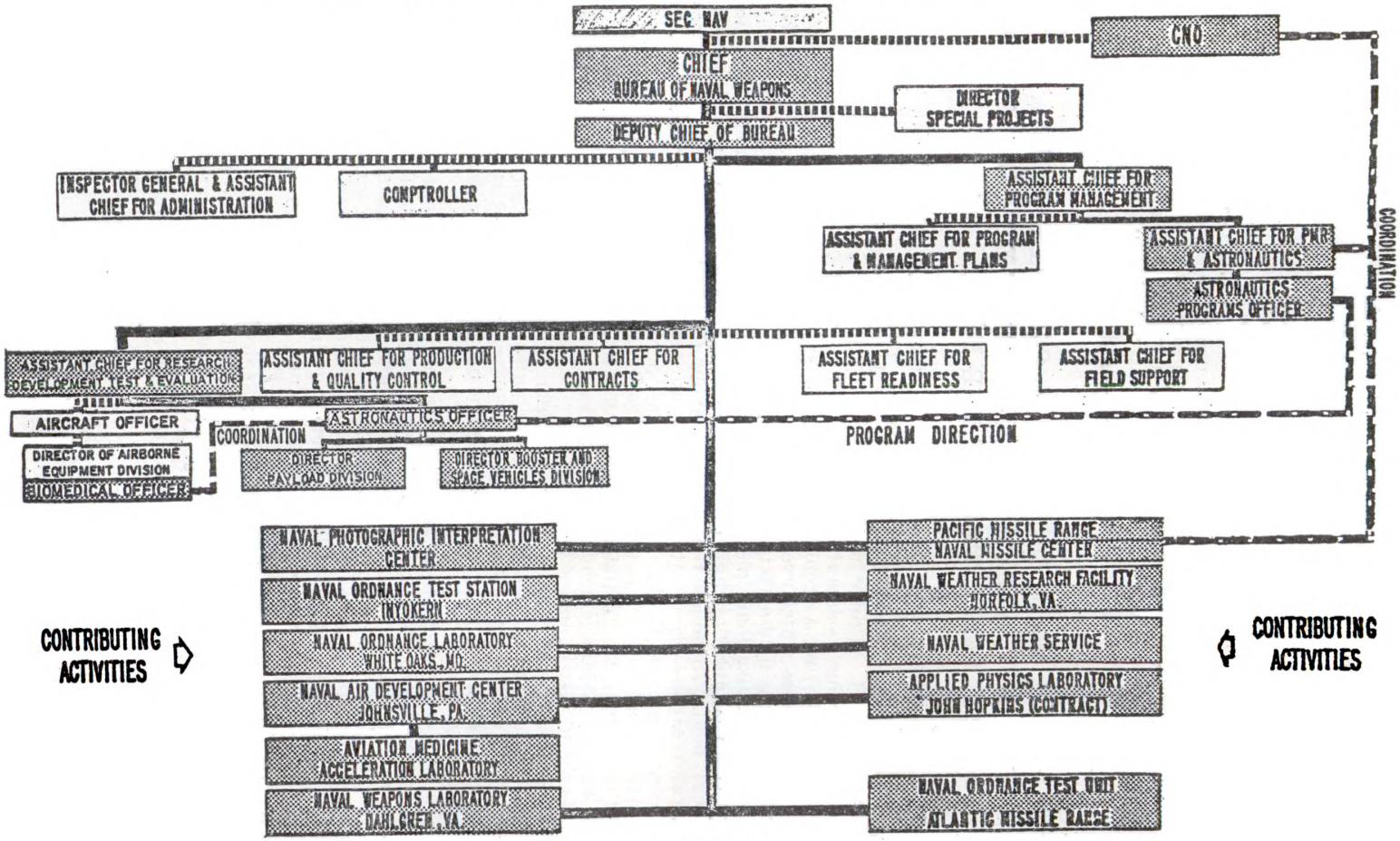

CHART 1

Astronautics area of cognizance. As such, he provides a specific point of contact for coordination, guidance, and assignment of resources to astronautics programs which are being conducted under the management of the Bureau of Naval Weapons.

The Assistant Chief of the Bureau for Research, Development, Test, and Evaluation is directly responsible to the Chief of the Bureau for the complete development of aircraft, weapons, and associated equipment with program management and direction in the astronautics area being the responsibility of the Assistant Chief for Pacific Missile Range and Astronautics. Under the Assistant Chief are four subgroups charged with the development of systems and components in the areas of aircraft, missiles, antisubmarine warfare, and astronautics. The astronautics subgroup consists of two divisions, payloads and vehicles, from which the Navy navigational and biomedical programs are being prosecuted.

PACIFIC MISSILE RANGE HISTORY, MANAGEMENT, AND OPERATIONAL CONCEPTS

History

The Pacific Missile Range (PMR), managed by the Navy, is one of the three national missile ranges, each having unique capabilities and different but complementary missions. The PMR mission is to provide range support for the Department of Defense and other designated Government agencies in guided missile, satellite, and space vehicle research, development, evaluation, and training programs in the Pacific Ocean area.

The PMR had its inception in December 1957 as a result of increased emphasis on missile and satellite programs and recognition of the necessity for adequate range facilities. The Naval Missile Center, Point Mugu, is the nucleus upon which the full Pacific Missile Range is being developed. This center, an operating missile range for 12 years, is manned by over 5,000 military and civilian personnel who are thoroughly trained and experienced in range operations. Its major complex before expansion consisted of a 75- by 150-mile sea test range off the coast of California. In this area the Navy had conducted thousands of tests of conventional types of guided missiles. The development and testing of these types of Navy missiles will continue at the Naval Missile Center with the Pacific Missile Range providing all the range support.

In June 1958 the PMR was officially established as a national facility with the Navy as executive agent. The Point Arguello area is being developed primarily in support of national astronautics and space effort, since it contains many deep canyons wherein large, dangerous noisy rockets can be isolated, plus a unique east-west coastline which allows firings into polar orbit without passing over any land between Point Arguello and the South Pole, thus making this area the most desirable rocket launching center on the U.S. mainland for launching satellites into these orbits. In addition, Arguello provides range services to launchings from Vandenburg Air Force Base to the north and to missile flights in the adjacent Pacific areas.

Operational concepts

The Navy has reviewed all firm missile and space programs requiring PMR support in order to prepare a long-range plan for future development of the range. This plan involves the establishment of a complex of ranges, capable of supporting the various types of missile and satellites to be developed. This complex includes: (*a*) A 250-mile sea test range, (*b*) a 1,500-mile IRBM range, (*c*) over 5,000-mile ICBM range terminating near Eniwetok Island, (*d*) a polar orbit range originating at Point Arguello, and (*e*) an antimissile range in the Kwajalein Atoll in support of the Army's Nike-Zeus antiballistic missile program which will provide capability for testing antimissile missiles, using as targets ballistic missiles fired from the Vandenburg Air Force Base on the west coast and from Johnston Island.

Under strong naval management, the Pacific Missile Range utilizes three contractors for specialized technical range operations and development areas—one in the eastern Pacific and another in the western Pacific. The third major range contractor is in the range development area to help assure that the range will expand in a planned and organized manner, anticipating and being ready for the demands placed upon it. This contract system was evolved after careful and detailed studies of the contract operations of the other national ranges. This study concluded that a single range contractor operation was undesirable because such an overall operation control might take over the management

control function which is properly the responsibility of the range commander. Conversely, it was determined that to go to a system utilizing a large number of small contractors, could prove to be a major management headache. The Pacific Missile Range tricontractor system appeared to be a sound, logical, middle-of-the-road approach and is meeting with excellent success.

The CHAIRMAN. All right, then, if there is nothing further, we can move into executive session at this point.

(Whereupon, at 11:15 a.m., the committee proceeded in executive session.)

(The executive session is classified and will not appear here.)