REVIEW OF THE SPACE PROGRAM

TUESDAY, FEBRUARY 16, 1960

House of Representatives,
Committee on Science and Astronautics,
Washington, D.C.

The committee met at 2:30 p.m., Hon. Ken Hechler presiding.

Mr. Hechler. The committee will come to order.

Today we have testimony by Abraham Hyatt, Deputy Director, Launch Vehicle Programs, for NASA.

Mr. Hyatt, do you have a prepared statement?

Mr. Hyatt. No, sir, I do not.

Mr. Hechler. Do you have some comments you wish to make?

Mr. Hyatt. Yes, sir.

Mr. Hechler. Proceed in your own way, Mr. Hyatt.

STATEMENT OF ABRAHAM HYATT, DEPUTY DIRECTOR, LAUNCH VEHICLE PROGRAMS, OFFICE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Hyatt. May I have your permission to speak near the charts?

Mr. Hechler. Yes.

Mr. Hyatt. Mr. Chairman and gentlemen, in earlier testimony Dr. Dryden and Mr. Horner have informed you about the national booster vehicle programs and mentioned the vehicles that make up this program. I shall discuss the vehicle program in greater detail and also bring you up to date on the developmental status.

Before I do that, I would like to mention three points:

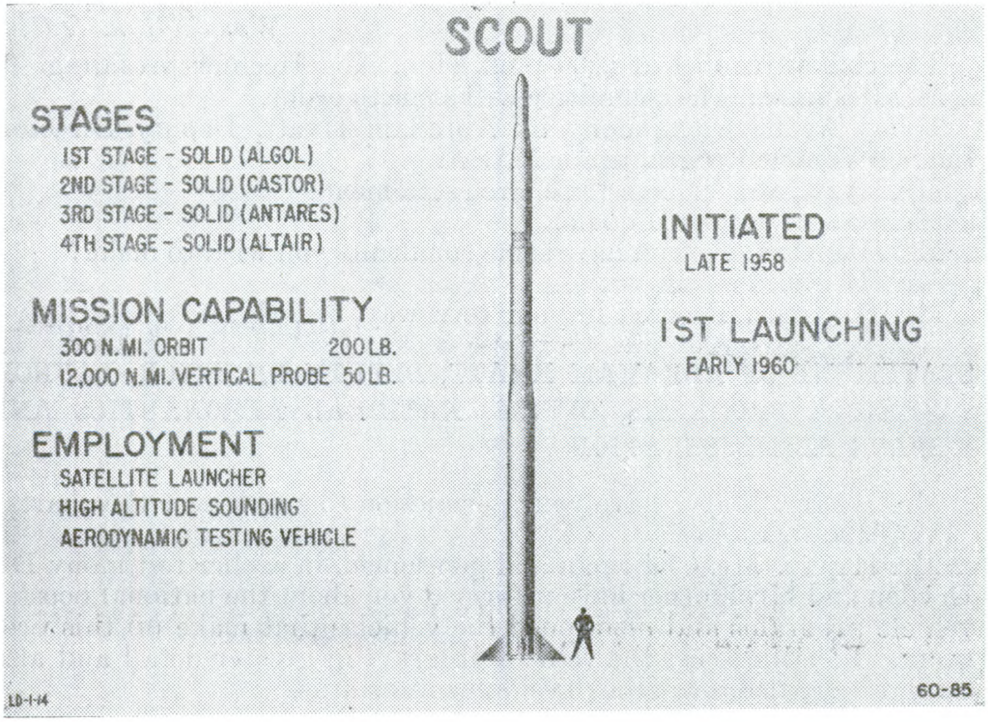
The first point is that the state of the art in vehicle development is not such that a new vehicle can be designed, manufactured and launched with an expectation of a high probability of success for the early flights. In every one of these space vehicles there are hundreds of sequential operations that must all work successfully, otherwise the vehicle will fail.

The second point is that in the future our vehicles will be larger, they will be designed to perform more complicated missions over a wider range of environmental conditions and for much longer periods of time. Consequently more vehicles will have to be assigned to the development phase if we want to have a high degree of confidence for the operational vehicles.

Finally, in order to minimize the effects of these two situations, every effort is being made to develop the smallest number of vehicles which will encompass the entire range of presently envisioned missions. It is the objective of the NASA to use every vehicle type for a number of missions even though each vehicle may not be optimum for every one of the missions. This allows us, in time, to use the same type of vehicle over and over again, thereby achieving a high degree of reliability. And of course, as we attain reliability, we experience fewer failures and achieve our objectives faster and more economically.

The vehicles that I shall discuss begin with the Scout vehicle (fig. 140). This is a four-stage solid propellent vehicle.

It will be capable of as much as 200 pounds of weight into an orbit at 300 nautical miles altitude above the earth and we can have a vertical probe straight up in the air as high as 12,000 miles with a payload of 50 pounds. The Scout will be used for launching of satellites, for high-altitude probes and for aerodynamic testing of the vehicle.



SCOUT

STAGES
1ST STAGE - SOLID (ALGOL)
2ND STAGE - SOLID (CASTOR)
3RD STAGE - SOLID (ANTARES)
4TH STAGE - SOLID (ALTAIR)

MISSION CAPABILITY
300 N. MI. ORBIT 200 LB.
12,000 N. MI. VERTICAL PROBE 50 LB.

EMPLOYMENT
SATELLITE LAUNCHER
HIGH ALTITUDE SOUNDING
AERODYNAMIC TESTING VEHICLE

INITIATED
LATE 1958

1ST LAUNCHING
EARLY 1960

LD-1-14

60-85

FIGURE 140

For the last mission, what might be done is fire, say, two stages upwards, turn the vehicle through 90 degrees, fire the remaining stages horizontally, and achieve very high speeds in the dense atmosphere. Or, the last two stages might be turned through and shoot 180 degrees, fired downward and achieve very high speeds into even denser atmospheres.

The Scout was initiated late in 1958 and we expect our first launching in early 1960 (fig. 141).

The guidance is all self-contained. Its position in the vehicle is shown here in this cutaway. The individual stages are also shown. The green portion is the solid propellant. The guidance package is relatively inaccurate compared to that contained in future vehicles. No commands from the ground are transmitted to the vehicle after it leaves the launcher.

Mr. McDONOUGH. You mean that the guidance has to be set before you fire for what purpose you want it designed for?

Mr. Hyatt. That is right. It has to be programed. Once the vehicle fires and takes off, there is no further guidance command given to it from the ground.

Mr. McDonough. What elevation would you get on the third stage there? Where would you be?

Mr. Hyatt. There is a command guidance from this package to the control at this stage, and it gives the signal for this stage to drop off, then it gives the signal for this stage to fire, gives the signal for this stage to drop off, this one to fire, etc. In other words all guidance and control commands are programed into and given by the self-contained guidance package.

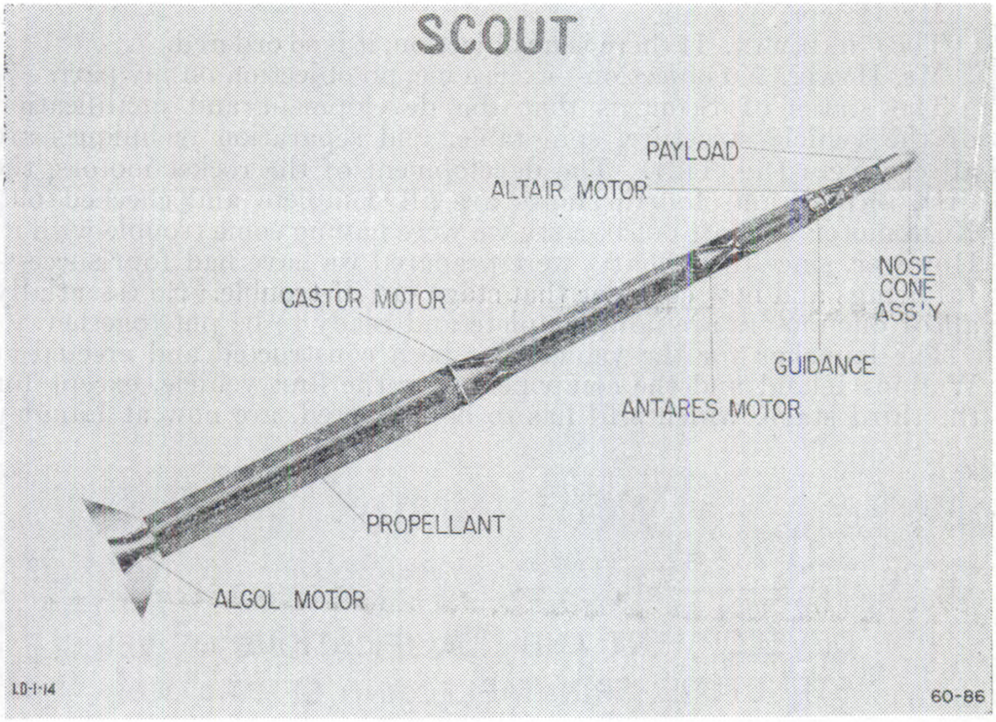


Figure 141

Mr. Fulton. Mr. Chairman.

The Chairman (Mr. Brooks). May I ask you a question? Do you know what thrusts the Russians used in their Pacific shots?

Mr. Hyatt. The answer is "I don't know." I have seen a lot of guesses, but I don't know accurately what their thrust was.

The Chairman. A high range of thrust, though, wasn't it?

Mr. Hyatt. You are referring to the ballistic missile shot of some 7,500 miles or so?

The Chairman. Yes, 7,800 miles.

Mr. Hyatt. Well, let me just make a guess. Since we don't know its payload, let us assume that it is of the same order as our own ballistic missiles, then the thrust required should be about the same as our own ballistic missiles.

Mr. Fulton. The same as the Atlas, isn't it?

Mr. Hyatt. It could be the same as the Atlas.

The CHAIRMAN. To return to your presentation, why do you have four stages in that relatively small missile?

Mr. HYATT. This is the only way we can achieve the end velocities to put a payload of this kind in orbit, without building an inordinately large vehicle. By staging smallness is achieved. This whole vehicle only weighs 32,000 pounds. If we were to try to do it with a single stage, we may have to go up to a weight of 300,000 pounds and still not be able to do it.

The CHAIRMAN. Mr. Fulton?

Mr. FULTON. May we have the charts put in the record, the drawings, so we can see them?

The CHAIRMAN. Do you have a smaller version of them?

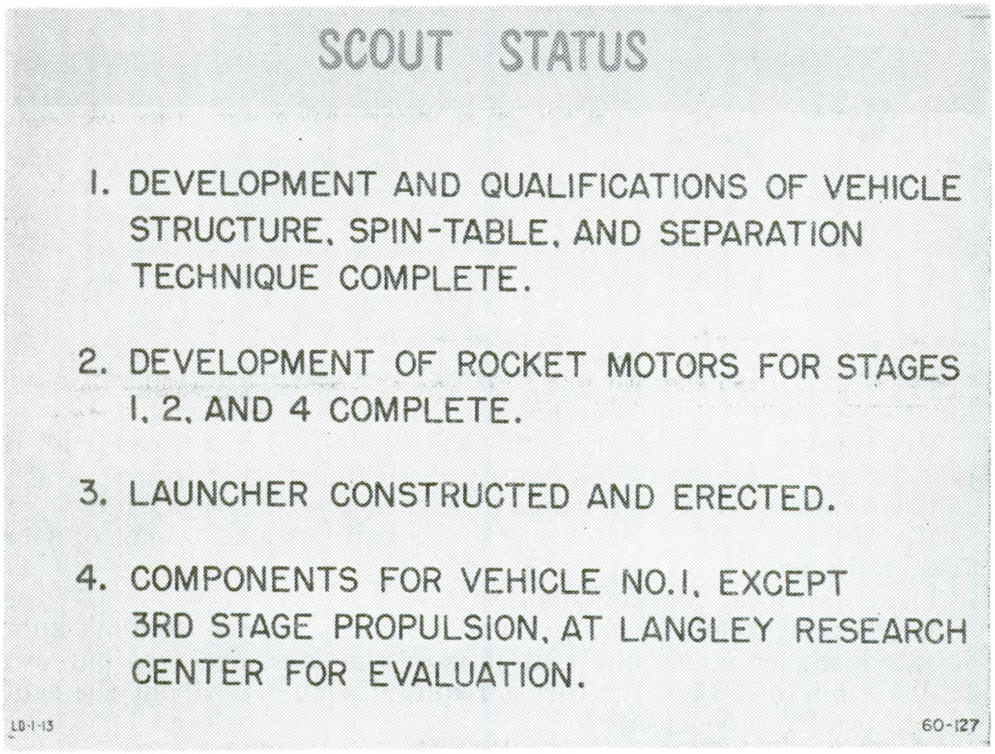
Mr. HYATT. Yes, sir.

The CHAIRMAN. If there is no objection, it is so ordered.

Mr. HYATT. No objection—excuse me, no objection on my part.

The status of Scout is that the development and qualification of the vehicle structure, spin table, and separation techniques are all complete (fig. 142). The development of the rocket motors, the first, second, and fourth stages are all complete and checked out. No. 3 motor was left out because we were having some trouble with it. However, since these charts were prepared we have had four successful firings and now consider that stage out of trouble. So essentially all of our motors are now complete and ready to be put together.

The launcher for the vehicle has been constructed and erected at Wallops Island and the components for the first vehicle, except for the third stage, which still has to be delivered, are now at Langley



SCOUT STATUS

1. DEVELOPMENT AND QUALIFICATIONS OF VEHICLE STRUCTURE, SPIN-TABLE, AND SEPARATION TECHNIQUE COMPLETE.
2. DEVELOPMENT OF ROCKET MOTORS FOR STAGES 1, 2, AND 4 COMPLETE.
3. LAUNCHER CONSTRUCTED AND ERECTED.
4. COMPONENTS FOR VEHICLE NO.1, EXCEPT 3RD STAGE PROPULSION, AT LANGLEY RESEARCH CENTER FOR EVALUATION.

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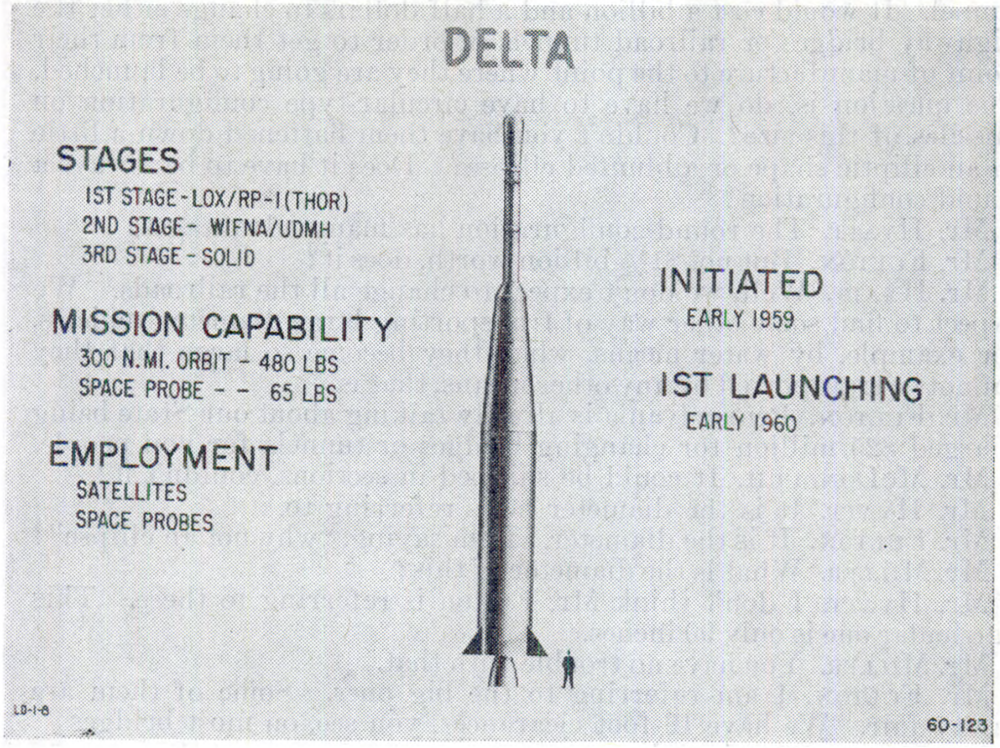
FIGURE 142



DELTA

STAGES
1ST STAGE - LOX/RP-1 (THOR)
2ND STAGE - WIFNA/UDMH
3RD STAGE - SOLID

MISSION CAPABILITY
300 N.MI. ORBIT - 480 LBS
SPACE PROBE - - 65 LBS

EMPLOYMENT
SATELLITES
SPACE PROBES

INITIATED
EARLY 1959

1ST LAUNCHING
EARLY 1960

FIGURE 143

Research Center for evaluation. After evaluation all parts will be assembled, checked out, and fired.

The next vehicle is the Delta (fig. 143). It is a three-stage vehicle with the first stage based on the Thor IRBM. The second stage is a slightly modified version of a stage previously used in Vanguard and Thor-Able shots. The fourth stage is the same as the third stage of the Scout. This vehicle will lift as much as 380 pounds into a 300 nautical mile orbit and 150 pounds into an escape trajectory. It will be used for satellite applications and space probes. The development was initiated early in 1959, and our first launching is expected within a couple of months.

We have 12 of these vehicles on order.

I might mention the guidance for the Delta. Ground command guidance is employed for the first two stages. Commands to follow the prescribed trajectory, to cut off first-stage firing, to separate it, to initiate second-stage firing, and to stop it are all given from the ground. From this point internally provided guidance takes over. A coast period follows second stage cutoff. During this time programed internal guidance shapes the trajectory, directs the third stage to spin up, the second stage to separate, and the third stage to fire. No further guidance other than spin stabilization takes place after the third stage is fired.

Mr. FULTON. I have one question.

The CHAIRMAN. Yes, Mr. Fulton.

Mr. FULTON. The question comes up on the transporting of these missiles. I understand that the diameter is too high to get them through the average highway bridge and through the average railway tunnel. It would cost a billion and a half dollars to change either the highway bridges or railroad tunnels in order to get them from their point of manufacture to the point where they are going to be launched. The question is, do we have to have circular-type configuration on missiles of this size? Couldn't you have them flattened down a little in an elliptic shape or a blunted ellipse? Does it have to be always a round configuration?

Mr. HYATT. The round configuration has many advantages.

Mr. FULTON. But not \$1½ billion worth, does it?

Mr. HYATT. Well, we don't expect to change all the railroads. We expect to find some other way of transporting large diameter vehicles, for example, by water means, when they become so large that they cannot be transported by any other means, that is.

Mr. FULTON. Pennsylvania is already talking about our State being charged \$25 million for changing bridges or tunnels for you people.

Mr. McDONOUGH. It could be shipped in sections, couldn't it?

Mr. HYATT. It is the diameter he is referring to.

Mr. FULTON. It is the diameter. I am saying, "why not an ellipse"?

Mr. MILLER. What is the diameter of this?

Mr. HYATT. I don't think Mr. Fulton is referring to these. This particular one is only 90 inches.

Mr. MILLER. You have no trouble with that.

Mr. FULTON. I am referring to the big ones. Some of them are pretty fair. We have 16-foot clearances, you see, on most bridges.

Mr. HYATT. That is right.

Mr. FULTON. Fourteen feet.

Mr. HYATT. Actually, our largest missile today is some 10 feet in diameter, but we are planning to build some as large as 20 feet in diameter.

Mr. FULTON. On the new highway program there have been some bridge tunnels 14 feet high. I am wondering if you people doing this testing have tried flattening them into an ellipse.

Mr. HYATT. I have not studied that point, but I would hazard a rather firm guess that it would be a serious penalty for us to design them that way.

Mr. FULTON. Put a statement in, will you?

Mr. MILLER. Jim, if you do that, wouldn't you be robbing Peter to pay Paul? If these things are 20 feet in diameter, you couldn't take them on the highways anyway, and if you made them into an ellipse you would be narrowing one diameter and lengthening the others.

Mr. FULTON. Yes.

Mr. HYATT. Yes. There are many technical reasons, too, for not using elliptical shapes. The tanks are internally pressurized. The circular shape is best to resist such pressures in a hoop tension manner. But if you had something other than a circle, then the internal pressure would want to push that shape out into a circle. Therefore increased strength in bending would have to be provided and that means added weight, and so on.

Mr. MILLER. Wouldn't you practically build these big ones on the ground?

Mr. McDONOUGH. At the point of launch.

Mr. HYATT. We expect to build them at some factory and then ship them to the point of launch.

The CHAIRMAN. Do you take into consideration the condition of the roads and bridges when you let a contract?

Mr. HYATT. Yes, sir.

The CHAIRMAN. You do?

Mr. HYATT. The contractor is required to propose how he would ship the constructed vehicle from his plant to the point of launching.

The CHAIRMAN. So if the plant were Pennsylvania and the bridges were low there, you would award it, maybe, to West Virginia, instead, if the bridges there were all right?

Mr. MOELLER. Or Ohio.

Mr. FULTON. Perish the thought. [Laughter.]

Mr. MILLER. Dr. Hechler looked up. It is the first time he has shown any——

Mr. FULTON. There is a point here where the cost proposed for railroads or for highway bridge changeovers is going to be a billion and a half dollars for the next generation missiles. That is the most recent estimates we have. So it is no small question. It isn't a question of just——

Mr. MILLER. It is a big question.

Mr. FULTON. It may isolate California from the rest of the country. [Laughter.]

Mr. MOELLER. Is air transportation forbidden here?

Mr. HYATT. No, sir; it is not. There is a possibility of air transportation, but not necessarily with an airplane-type vehicle.

The CHAIRMAN. I think the whole highway problem is a big one. Sometimes I think it is a big mess. But I think we had better get back to the space program.

Mr. HYATT. All right, sir.

Now, the status of the Delta vehicle (fig. 144, p. 732) is that the first, second, and third stages have been delivered to the Atlantic Missile Range for the first vehicle. The complete third stage has been successfully flight-tested in two separate firings, and the hardware for the remaining vehicles is on schedule. This vehicle is progressing nicely and we are quite satisfied with its progress.

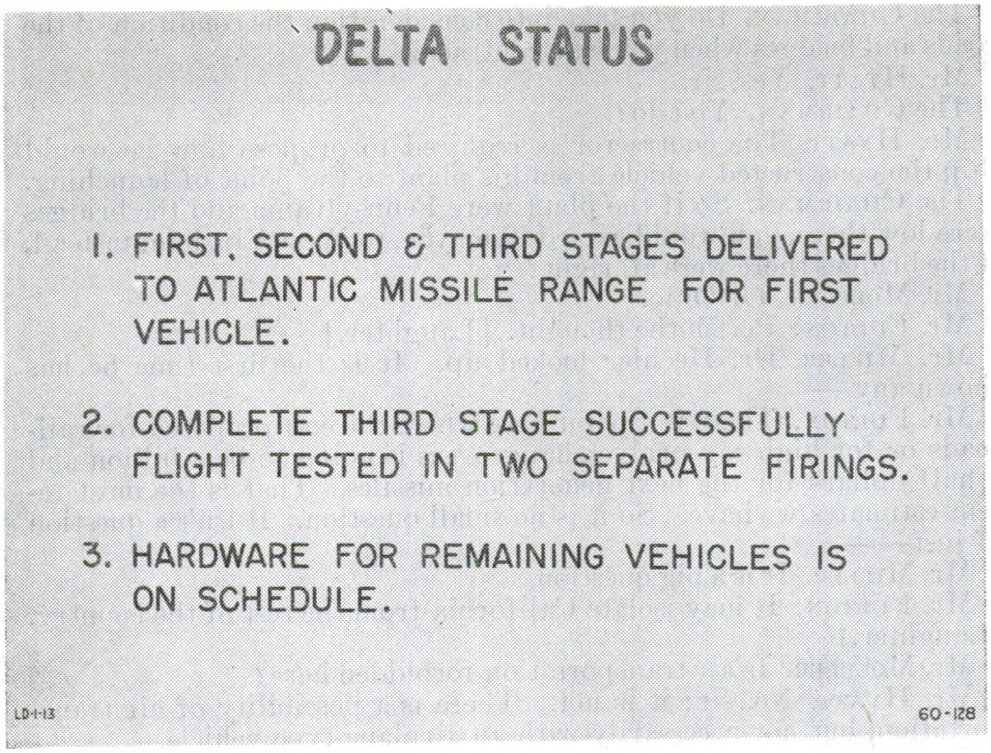
The Centaur vehicle is shown on the next chart (fig. 145, p. 732). You will recall that the first stage is a modified Atlas and the second stage is one that uses high-energy propellants, liquid oxygen and liquid hydrogen.

I would like to just mention that liquid oxygen has a liquid temperature of minue 290° F. At some value higher than that it is a gas. Liquid hydrogen has a liquid temperature of minus 422° F. Also liquid hydrogen is about one-sixteenth as heavy as liquid oxygen, so those two characteristics present us new problems.

Because of its high-energy upper stage, the Centaur has a capability of putting as much as 8,500 sounds into a 300-nautical-mile orbit and as much as 450 pounds into a planetary probe. The vehicle will be used for lunar and planetary explorations and also has the possibility of a 24-hour communications satellite, plus numerous other uses.

The Centaur vehicle (fig. 146, p. 733) was initiated by the Department of Defense in late 1958. It was turned over to NASA for development on July 1, 1959. We expect the first launching in mid-1961.

I have a cutaway of the Centaur (fig. 147, p. 733) that I thought you might like to see. This is the first stage with its three engines. At



DELTA STATUS

1. FIRST, SECOND & THIRD STAGES DELIVERED TO ATLANTIC MISSILE RANGE FOR FIRST VEHICLE.
2. COMPLETE THIRD STAGE SUCCESSFULLY FLIGHT TESTED IN TWO SEPARATE FIRINGS.
3. HARDWARE FOR REMAINING VEHICLES IS ON SCHEDULE.

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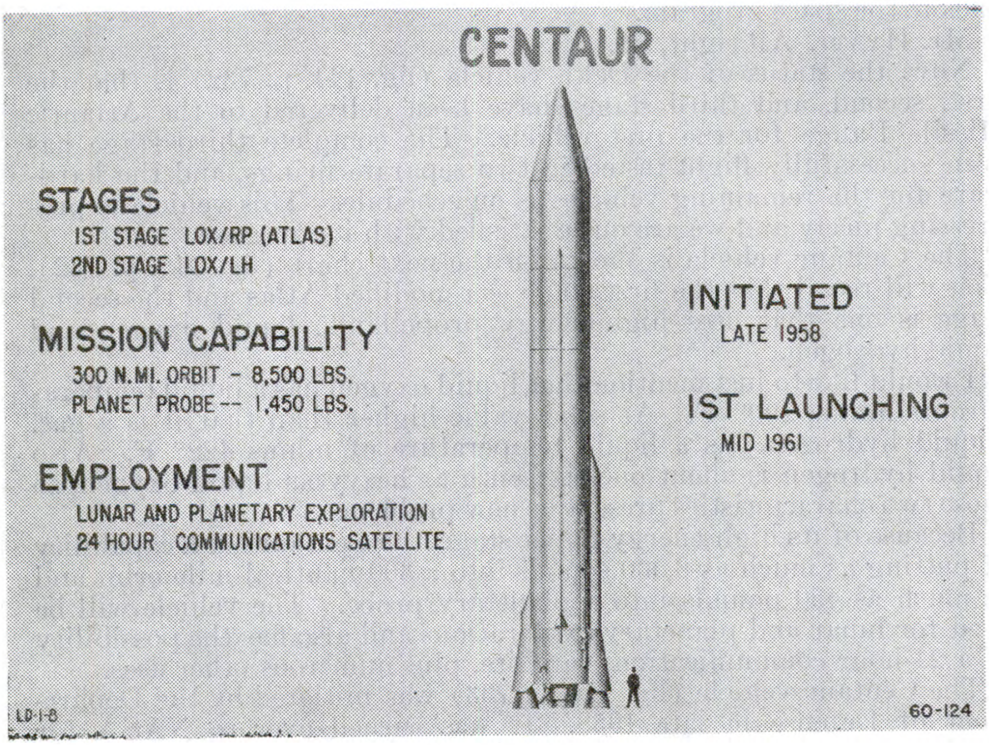
FIGURE 144



CENTAUR

STAGES

1ST STAGE LOX/RP (ATLAS)
2ND STAGE LOX/LH

MISSION CAPABILITY

300 N.MI. ORBIT – 8,500 LBS.
PLANET PROBE -- 1,450 LBS.

EMPLOYMENT

LUNAR AND PLANETARY EXPLORATION
24 HOUR COMMUNICATIONS SATELLITE

INITIATED

LATE 1958

1ST LAUNCHING

MID 1961

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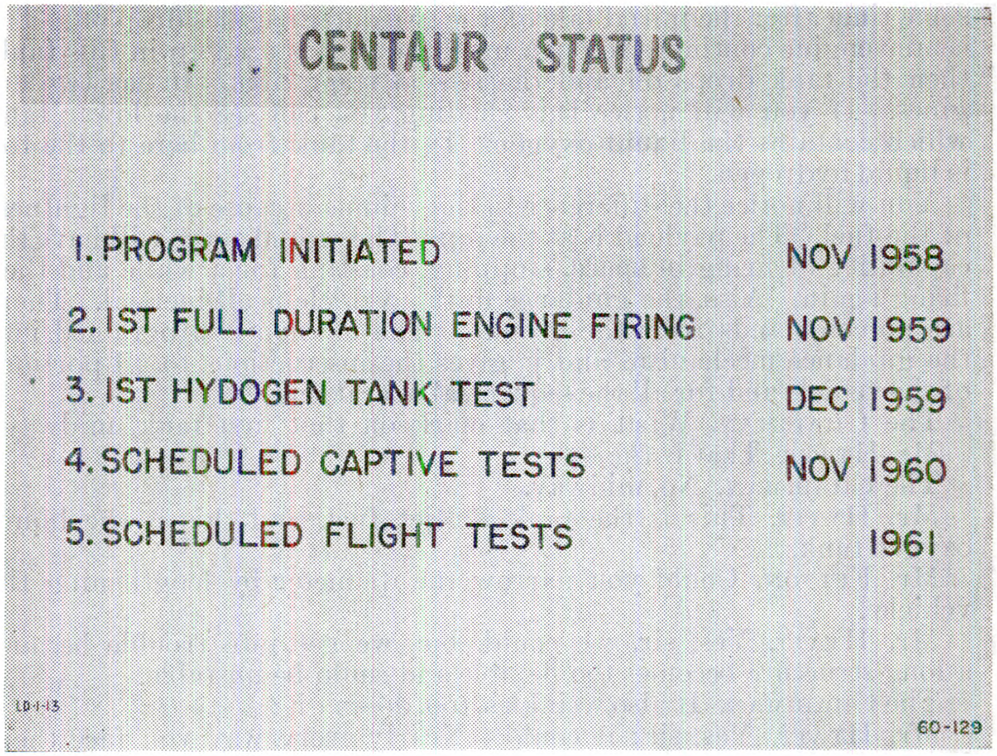
FIGURE 145



CENTAUR STATUS

1. PROGRAM INITIATED NOV 1958
2. 1ST FULL DURATION ENGINE FIRING NOV 1959
3. 1ST HYDOGEN TANK TEST DEC 1959
4. SCHEDULED CAPTIVE TESTS NOV 1960
5. SCHEDULED FLIGHT TESTS 1961

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FIGURE 146

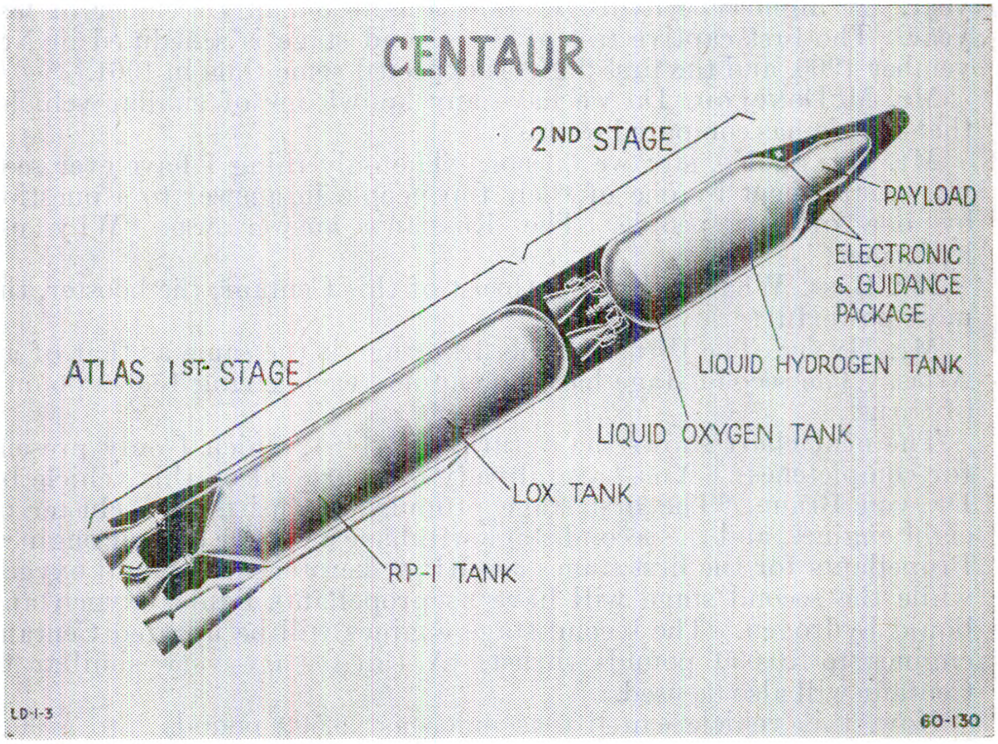


FIGURE 147

some time after the initial takeoff the two outer engines drop off. The center engine continues to burn until the fuel is used up in this tank, then the tank drops off and the second stage fires. It has two engines. If you will notice this shading you can see the lower tank which contains the liquid oxygen. In the tank from here to the top is liquid hydrogen.

You will notice the difference in the volume because of the lightness of the fuel. The payload is at the top. The second stage will have the capability of firing in space, stopping, coasting for a while and then firing again. Also, the guidance in this vehicle is all inertial. There are no commands from the ground. The mission is programed into the guidance mechanism and it gives the instructions to all portions of the vehicle and for all the sequential operations.

The CHAIRMAN. What is that mark on that first tank, midway?

Mr. HYATT. That is the——

The CHAIRMAN. No, midway.

Mr. HYATT. This is the tank for jet fuel, and this is the liquid oxygen tank.

Mr. FULTON. Could you narrow the diameter by lengthening the vehicle?

Mr. HYATT. Yes, sir, we could, but we get into trouble because a long structure becomes too flexible and could be unstable.

The CHAIRMAN. It also wrinkles, too, doesn't it?

Mr. HYATT. Yes, sir; it could. Nearly every way you face there is some sort of technical obstacle. The state of this program is that we have had the first full duration engine firing November of last year. A flight-type hydrogen tank was tested in December of last year. The first captive test of the second stage is scheduled in November 1960, and the first flight is expected some time in 1961.

Mr. McDONOUGH. Do we have any knowledge of similar vehicles that Russia has compared to this?

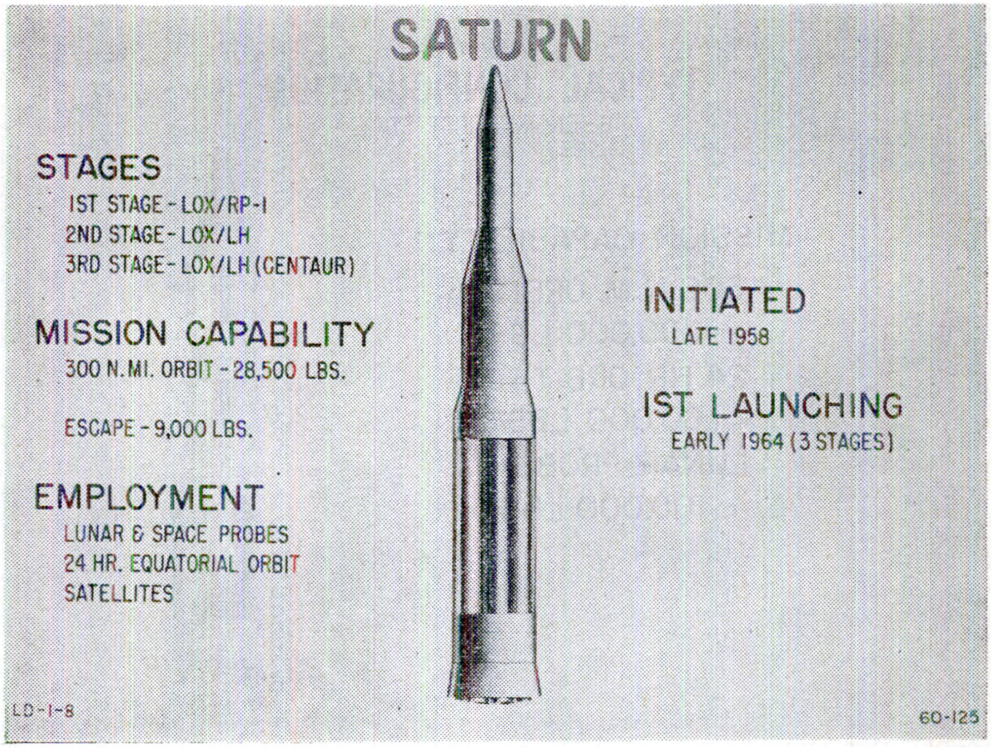
Mr. HYATT. No, sir; we do not. The only thing I have ever seen was a statement by one of their top people in answer to a question by one of our people. The Russian's answer was "Why use hydrogen?"

Mr. BASS. What will be the thrust of this Centaur, the booster, the most powerful?

Mr. HYATT. The thrust of the first stage is the same as that of an Atlas. The second stage has two engines, each giving 15,000 pounds of thrust.

The next chart shows the Saturn (fig. 148), which I only present for completeness. You have already been briefed on this vehicle by Dr. von Braun. The first stage propulsion consists of a cluster of eight engines, and the second stage will have a cluster of four engines. Propellants for the first stages are RP or kerosene and liquid oxygen while the second stage will have as propellants liquid oxygen and liquid hydrogen. The second-stage engines will be uprated Centaur engines to 20,000 pounds thrust. A third stage very similiar to Centaur will also be used.

Now, this vehicle can lift as much as 28,500 pounds into a 300-nautical-mile orbit. For a mission either to the Moon or probe into deep space, a payload of some 9,000 pounds can be accelerated to escape velocity. This vehicle will be used for lunar and space probes.



SATURN

STAGES
1ST STAGE - LOX/RP-1
2ND STAGE - LOX/LH
3RD STAGE - LOX/LH (CENTAUR)

MISSION CAPABILITY
300 N. MI. ORBIT - 28,500 LBS.

ESCAPE - 9,000 LBS.

EMPLOYMENT
LUNAR & SPACE PROBES
24 HR. EQUATORIAL ORBIT
SATELLITES

INITIATED
LATE 1958

1ST LAUNCHING
EARLY 1964 (3 STAGES)

FIGURE 148

It can be used for a 24-hour equatorial orbit communications satellite, and other kinds of satellites. The program was initiated in late 1958. The first launching of a three-stage vehicle that might be considered as operational, that is, the 11th vehicle of a vehicle development program, is expected in early 1964.

Mr. FULTON. Mr. Chairman.

The CHAIRMAN. Mr. Fulton.

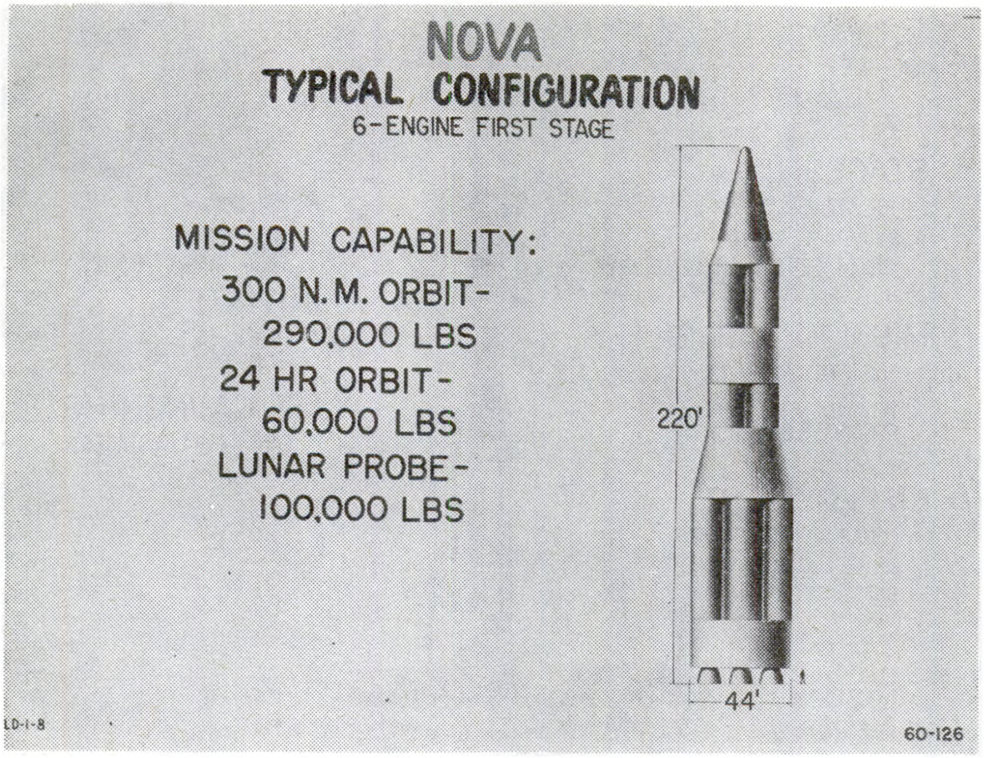
Mr. FULTON. You are going to launch that from Cape Canaveral and you are manufacturing it over in Redstone Arsenal, Ala. How are you going to get that behemoth to the Cape?

Mr. HYATT. By water. There is a specially developed and equipped barge being constructed. The first stage will be transported on a special truck to the barge dock on the Tennessee River, then the barge will be towed down the Tennessee and Ohio, down the Mississippi to the gulf, around the tip of Florida and up to Canaveral.

The CHAIRMAN. Down the intracoastal canal into Florida.

Mr. HYATT. Now I'll review quickly the developmental status of the Saturn. The first stage is under construction, much of it has been built. The test facility at Huntsville is practically complete. We are constructing a launch facility at Canaveral, and just within the last month we have requested industry to submit proposals for the construction of the second stage.

The last launching vehicle I wish to discuss is the Nova (fig. 149, p. 736). I must point out it is only a concept, that we are not yet developing the vehicle itself. The only portion of it that is under development is the 1½-million-pound-thrust engine, which might be used in clusters to power the first and second stages.



NOVA
TYPICAL CONFIGURATION
6-ENGINE FIRST STAGE

MISSION CAPABILITY:
300 N.M. ORBIT-
290,000 LBS
24 HR ORBIT-
60,000 LBS
LUNAR PROBE-
100,000 LBS

FIGURE 149

If we had a cluster of six 1½-million-pound-thrust engines in the first stage, two in the second, one in the third, we could have the load-carrying capability shown: Some 290,000 pounds into a 300-mile orbit; into a 24-hour orbit some 60,000 pounds, and a load to the Moon of some 100,000 pounds.

Now, this is a——

The CHAIRMAN. That is just the bell. Go ahead.

Mr. HYATT. Now——

Mr. McDONOUGH. Mr. Chairman.

The CHAIRMAN. Mr. McDonough.

Mr. McDONOUGH. If this were operative and you did put into a 300-nautical-mile orbit 290,000 pounds, what would be the life of the 290,000 pounds in orbit?

Mr. HYATT. In a 300-mile orbit, it should stay there for a good many years.

Mr. McDONOUGH. And when it had lost its orbital velocity, when it had lost that and started coming back in, that wouldn't disintegrate coming through, would it?

Mr. HYATT. That is right. It would not all be consumed coming through the atmosphere.

Mr. McDONOUGH. Left over to land someplace?

Mr. HYATT. Land someplace; yes, sir.

Mr. McDONOUGH. And you couldn't control where it would land?

Mr. HYATT. Well, you could build into this vehicle a reentry capability. There is enough weight to do that. In that case its landing point could be controlled.

Mr. McDONOUGH. You could control where it lands or you could disintegrate it; one or the other?

Mr. HYATT. You could disintegrate it.

The CHAIRMAN. You haven't the capability built in now to reenter; you would have to build it in?

Mr. HYATT. You would have to build it in. You would have to construct the reentry vehicle so that it would have wings or other means of lift to control and land at a predesignated spot.

Mr. McDONOUGH. Do we have the capability of putting into a 300-nautical-mile orbit a quantity in excess of an amount that would disintegrate for reentry purposes?

Mr. HYATT. I am not sure that I understand your question, but if, for example, a steel ball one foot in diameter was in a circular orbit and it started coming back into the atmosphere, I don't believe it would burn up entirely, that the outside surface would melt some, but there would still be a good portion of it left to impact at some point on the earth.

Mr. McDONOUGH. We haven't got the capability of putting a ton up, have we?

Mr. HYATT. At this time, no.

Mr. McDONOUGH. No.

Mr. HYATT. Well, I will take that back. Mr. Low, in his next presentation for a very low orbit——

Mr. McDONOUGH. I don't want to get into anything classified. Is this the first time this has been revealed, this information that you are giving us now?

Mr. HYATT. I am not sure that Saturn has been explained before. Some of this was presented——

Mr. McDONOUGH. I am just wondering; is there any security officer around here? Are we asking for more than——

Mr. HYATT. As far as I can judge, I will not reveal anything that is classified.

The CHAIRMAN. So you are protecting yourself, then. All right.

Mr. FULTON. Nova could be used for a space platform, then, or possibly as a launching pad for other vehicles? We wouldn't have to take the vehicles off the ground if we could put them up 300 miles——

Mr. HYATT. Yes, sir; that is certainly——

Mr. FULTON (continuing). And had a method of getting them up there, and a much more accurate method of launch?

Mr. McDONOUGH. You mean automatically, not manned launchings?

Mr. HYATT. Launched from a space platform.

Mr. FULTON. Launched from a space platform, manned or otherwise?

Mr. HYATT. Yes.

Mr. RIEHLMAN. Isn't that more difficult than launching from the Earth, in order to hit a target?

Mr. HYATT. Right now, of course, we can't do it.

Mr. RIEHLMAN. I mean in time.

Mr. HYATT. It may actually offer advantages to launch from an orbit around the Earth. In fact, there have been studies made of launching vehicles from the ground, have them assembled in an orbit around the Earth and then launch your operation further into space from that orbit.

Mr. Fulton. Did I understand you to intimate we could at present put a ton in orbit? If so, I am pleasantly pleased and surprised.

Mr. Hyatt. Well, the Mercury program—mind you, I made the comparison of all the vehicles I discussed, for a 300 miles altitude orbit, 300 miles above the Earth. Into a low orbit, 100 miles altitude or so, the Atlas in the Mercury program will put up as much as a ton?

The next chart (fig. 150) shows all the vehicles we are now using. Some of these will definitely be phased out. I will just flip the transparent sheet and show what we hope to have left (fig. 151). Even some of these, for example, this one might be eliminated. And of course the Nova is just a plan now; it is not yet under development. So we wind up with the Scout, the Atlas that is used in Project Mercury, the Atlas Agena, Centaur, and Saturn as our stable of vehicles for space exploration.

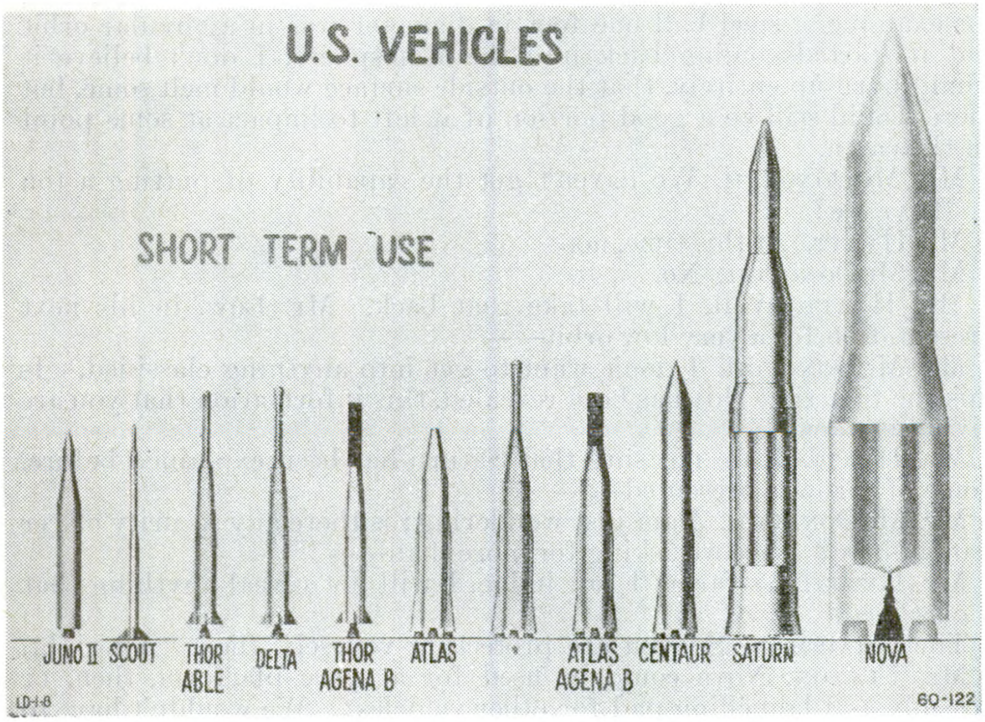


Figure 150

The Chairman. You will have five of them?

Mr. Hyatt. If we eliminate this one it is 1, 2, 3, 4, 5.

Finally, here is a quick résumé of the budget requests for fiscal 1960 and 1961 (fig. 152).

The Chairman. I hope you chairman of the subcommittees watch this very closely.

Mr. Sisk. We are watching, Mr. Chairman.

The Chairman. All right.

Keep an eagle eye open.

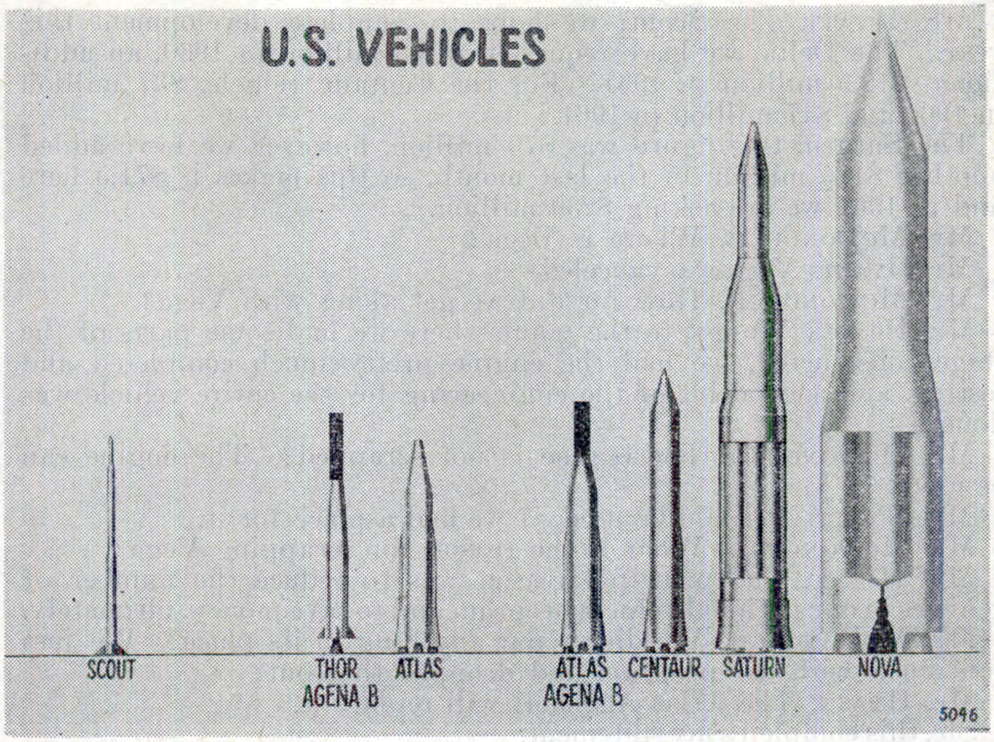
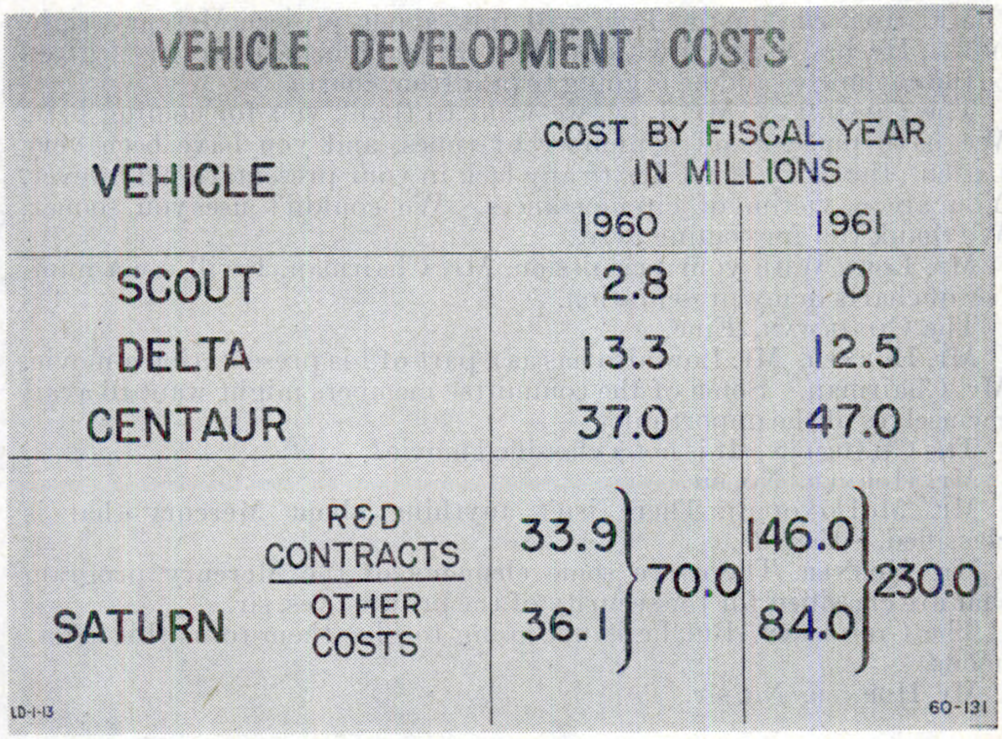


FIGURE 151



VEHICLE DEVELOPMENT COSTS

VEHICLE		COST BY FISCAL YEAR IN MILLIONS			
		1960		1961	
SCOUT		2.8		0	
DELTA		13.3		12.5	
CENTAUR		37.0		47.0	
SATURN	R&D CONTRACTS	33.9	70.0	146.0	230.0
	OTHER COSTS	36.1		84.0	

LD-1-13

60-131

FIGURE 152

Mr. Hyatt. The Scout, we hope to complete development this year. The Delta, we have requested $13.3 million in 1960, an additional $12.5 million in 1961. For the Centaur vehicle, $37 million in 1960 and $47 million in 1961.

The Saturn, this figure was $70 million, however we have added another $1½ million in the last month, so this makes it $71.5 here and in 1961 we are asking $230 million.

Mr. McDonough. Where is Vega?

Mr. Hyatt. Vega was canceled.

Mr. McDonough. How far did we get along with Vega?

Mr. Hyatt. We got to the point where we had some parts of the stage constructed, we had the engine pretty much completed and testing, and a good bit of the engineering for the entire vehicle was done.

Mr. McDonough. The engine is not scrapped? The engine can be used?

Mr. Hyatt. It could be used, if we had a place for it.

Mr. McDonough. What is the reason for scrapping Vega?

Mr. Hyatt. The principal reason was to reduce the number of vehicles in our national vehicle program and to save money, ultimately.

Mr. McDonough. We didn't put anything in its place? We just continued with the program and dropped that out?

Mr. Hyatt. The Atlas Agena B will replace it.

Sir, this completes my statement.

The Chairman. Fine, we thank you very much, Mr. Hyatt.

Now, who do we have next?

Mr. Horner. George Low will talk about project Mercury right now. He has a prepared statement which I believe has been given to the committee and he is going to talk from charts.

The Chairman. Mr. Low, we want to thank you for coming here. We have put you off a number of times, and you have been very patient, the delay is not due to any lack in your presentation, however. You are a victim of circumstances. We couldn't use you sooner. We thank you for coming here.

Mr. Low. With your permission, Mr. Chairman, I will use a number of charts in my presentation.

The Chairman. Fine.

Mr. Horner. Mr. Low also has as a part of his presentation a movie, Mr. Chairman. Some of the committee members might want to avail themselves of the opportunity——

The Chairman. It is not a classified movie?

Mr. Horner. No, sir.

Mr. McDonough. There isn't anything about Mercury that is classified, is there?

Mr. Horner. There are some elements of the Mercury program that are classified for the security of the project; yes, sir.

The Chairman. But he is not going to give them to us this afternoon?

Mr. Horner. No, sir.

STATEMENT OF GEORGE M. LOW, CHIEF, MANNED SPACE FLIGHT PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Low. Mr. Chairman and members of the committee, the subject of my discussion today is Project Mercury.

As you may recall from my presentation to this committee last year, Project Mercury represents this Nation's effort to launch and recover a manned satellite. The program's primary objective is to study man's capabilities in a space environment.

The project was conceived, and is being carried out, in a manner that will attempt to achieve manned orbital flight at an early date.

Let me now briefly review, with a few charts, some of the basic principles involved in this project.

My first chart shows the Mercury capsule system (fig. 153). When this satellite is launched into orbit it sits on top of an Atlas booster, with the small end pointed up. The capsule proper, or the satellite in which the man rides, is the large cone-shaped object. The capsule system also includes a package of small solid propellent rockets, used first to separate the capsule from its launching vehicle, and later on to return the capsule back from its orbit.

On top of the capsule is a tower-like structure—let me take one of the models here—and this tower holds another solid propellent rocket which is used to carry the capsule away from the booster, should the booster malfunction during the early stages of flight.

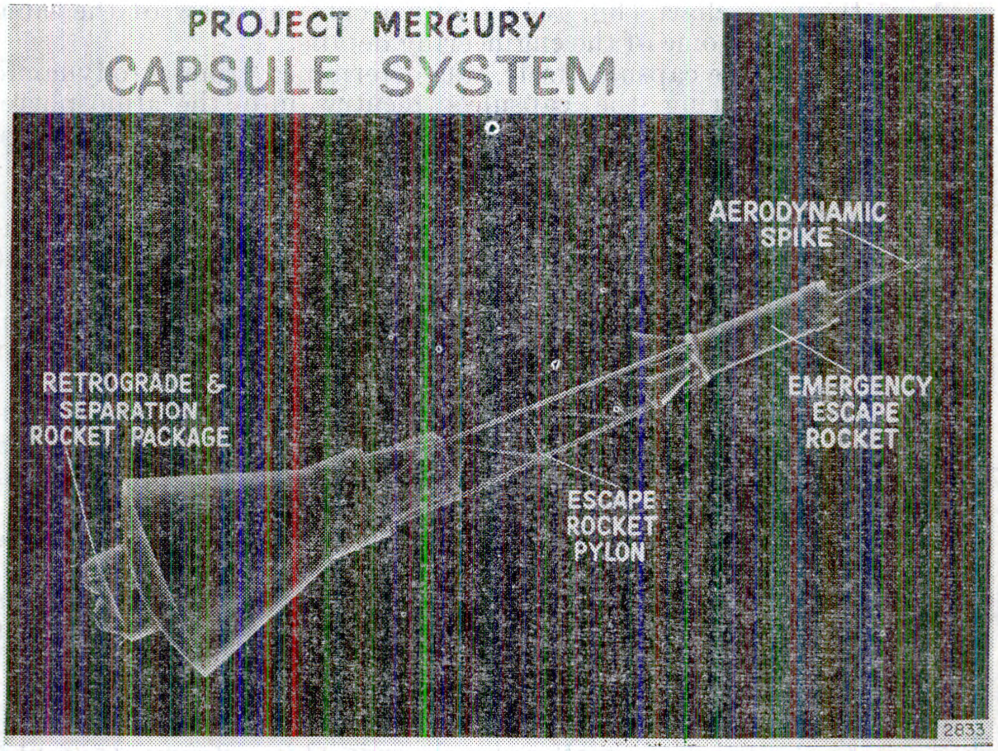


FIGURE 153

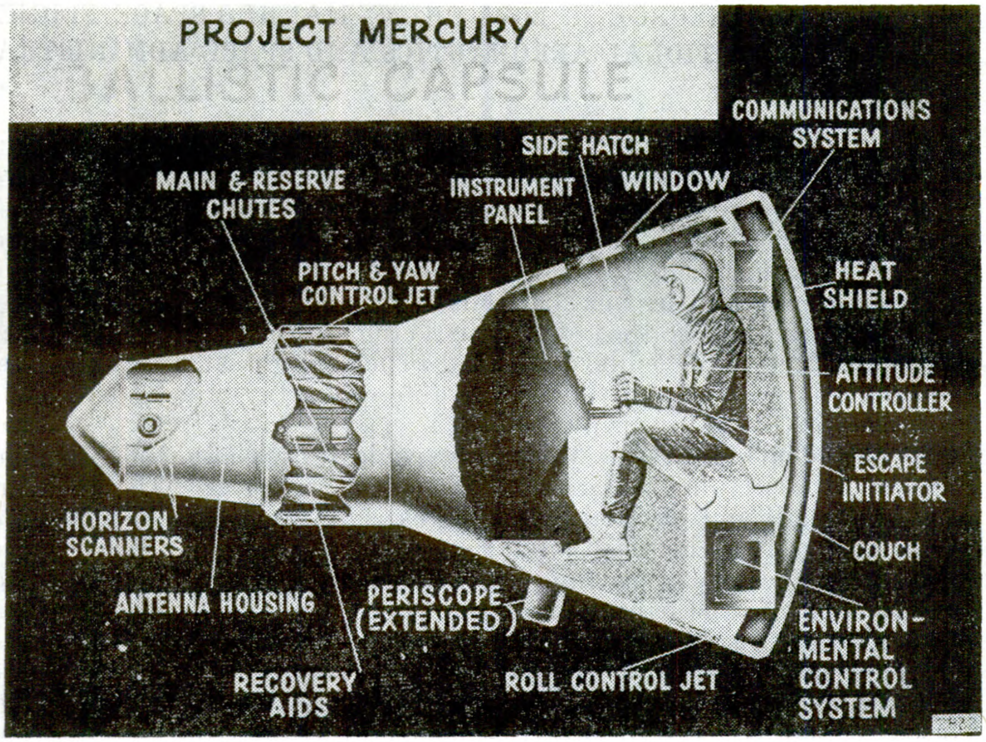


FIGURE 154

Now, the next chart (fig. 154) shows a cutaway view of the same capsule revealing some of the engineering details.

The shape of the capsule, itself, was determined from aerodynamic considerations during the capsule's reentry into the atmosphere. When the capsule returns to the atmosphere it will fly with the large blunt end pointed forward. The heat of reentry will then be dissipated by a plastic heat shield.

Within this pressure-tight capsule the pilot is supported in a form-fitting couch. When the capsule reenters the atmosphere the astronaut will be pressed back into the couch with eight times the force of gravity. Centrifuge tests have demonstrated that a man supported in such a couch can withstand considerably more than the number of g's that he will encounter in the Mercury mission.

The atmosphere within the capsule is controlled and kept within prescribed limits by an environmental control system. There is a communications system which transmits data to ground stations, and also allows the astronaut to talk to ground stations periodically.

While in orbit the capsule's attitude will be controlled. It will be stabilized, so that it is oriented in a prescribed direction. This will be done through infrared horizon scanners, which sense the capsule's attitude, and with small hydrogen peroxide jets which then can orient the capsule in the proper direction.

The CHAIRMAN. That is automatic, is it?

Mr. LOW. This is normally done automatically. But the pilot also has a manual attitude controller; by observing his instruments and by looking at the Earth through a periscope and then by using the manual attitude controller, he, himself, can also change the capsule's attitude.

In order to bring the capsule back down to earth the small solid propellent rockets housed at the blunt end of the capsule, and not shown in this chart, will be fired. These slow the capsule down by 350 miles an hour. This is just enough so that the Earth's gravity will slowly reassert itself and pull the capsule down toward the Earth atmosphere.

The capsule is then slowed down, by the drag of the air through which it flies, from almost its orbital speed of 17,500 miles per hour to a low speed of about 200 miles an hour. Then, at an altitude of 10,000 feet, a large cargo parachute is deployed. This parachute, and a second parachute for emergency purposes, is housed in the small end of the capsule. The capsule is then lowered by parachute to the Atlantic Ocean where it will be picked up by recovery ships.

Pictorially, this sketch indicates that the capsule is a relatively simple device; but such is not the case. It has been a major engineering task to design a capsule so that it can withstand the forces and the heating of atmospheric reentry, and yet is light enough so that it can be boosted into orbit. The design of subsystems that are highly reliable, and yet small enough to fit within the 6-foot diameter capsule has stretched the existing state of the art.

Perhaps the complexity of this device can best be illustrated by the fact that there are 7 miles of electrical wiring interwoven within the capsule to activate the various electronic systems and rockets, and the many other devices.

Now, there has been a great deal of discussion as to how much a pilot should be allowed to do in a space mission. We who are associated with Project Mercury believe that the pilot's role should be a very active one. Just how much he will be able to do can best be illustrated with a picture of the capsule's instrument panel (fig. 155, p. 744), as shown on the next chart.

The key to his entire participation is the sequence control panel.

On this panel there are a series of lights, switches, and buttons. The lights will come on green if any of a number of functions that the capsule systems are supposed to perform are performed automatically. However, if a function does not take place at the proper time, a red light will come on.

The pilot then has an independent circuit, activated by a switch that he can push to perform this function manually.

Mr. McDonough. When the red light appears, does it indicate which section is not operating properly?

Mr. Low. Yes, it does. For instance, illustrated here is a red light on for the retrorockets, the rockets that are supposed to be fired to bring the capsule out of orbit. If this light comes in this means that the retrorockets have not been fired automatically at the proper time. By pushing the button next to this light the pilot can light off the rockets himself to get himself out of orbit; and he can perform a dozen or so other functions.

The Chairman. What is the difference between retrorocket and the ground rocket? The ground rockets bring him down to 350 miles an hour?

Mr. Low. No, sir. The retrorockets are the ones that slow him down by 350 miles an hour. In orbit he is moving at about 17,500 miles an hour. These rockets slow him down by only 350 miles an

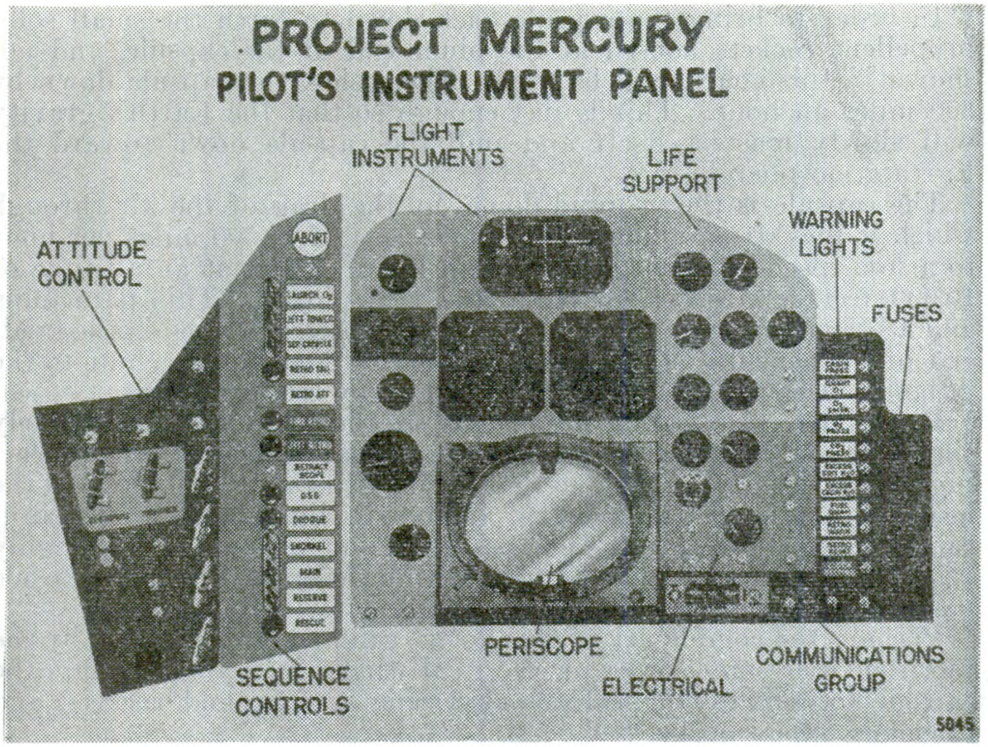


FIGURE 155

hour, so that his speed will still be somewhat more than 17,000 miles an hour. But the speed is just low enough, so that the Earth's gravity will pull the capsule back.

The CHAIRMAN. He is going 17,500 miles an hour and only reduces 350, and you get him out of orbit?

Mr. LOW. That is enough so that the gravity of the Earth will slowly pull the capsule back down out of orbit.

The CHAIRMAN. They don't have any other rockets to use near the ground?

Mr. LOW. No, sir.

On the lefthand panel the pilot has a series of controls that allow him to lock out the automatic control system and activate his manual control stick. Once he has locked out these automatic controls and has activated the manual ones, then with the flight instruments, and with a periscope through which he can see the ground, he can, himself, orient the capsule in any direction he desires.

Also on the lefthand panel is a valve to decompress the capsule and vent it to the outside vacuum. This he would use in case there should be a fire within the capsule or a buildup of toxic gases; in other words, it is his fire extinguisher. By venting the capsule to the outside atmosphere he would immediately put out the fire; he could then recompress the capsule by pulling another handle.

The CHAIRMAN. What do you mean by venting it?

Mr. LOW. To open the capsule to the outside vacuum. The pilot would open a small valve and open the capsule to the outside vacuum.

The CHAIRMAN. That would leave space inside.

Mr. Low. Of course, the pilot is still in his pressure suit; he wears a special pressure suit so that close to his body there will still be sufficient pressure to allow him to live. But the rest of the cabin will be evacuated, if he pulls this.

Mr. McDonough. He can shut that off?

Mr. Low. He can then shut that off and pull a second handle to build up the pressure within the capsule again.

The instruments on the right-hand side of the panel have to do with his life support system. The various gages record the pressures, temperatures, and the gas composition within the capsule. If, for instance, the carbon dioxide builds up to too high a level, the astronaut will note this on one of the gages and will be able to purge the capsule with more oxygen. On another panel are gages to tell him how the electrical system is functioning, and the various dials for the communication system. A series of warning lights are provided to indicate the malfunctioning of various systems.

By looking at this panel we can see that the pilot's participation in the Mercury mission will be a very active one.

Now, a project as complex as Mercury could not be carried out without a very extensive research and development program. At the end of my presentation I will show a film that will show what we have accomplished in this research and development program during the past year.

But before I show the film I would like to briefly run through a few more charts to show the flights that we expect to take place during the next year or two.

Mr. McDonough. Mr. Low, has the condition that you have described been simulated with a man in the capsule? For instance, your opening the vent and closing the vent, has that been simulated?

Mr. Low. It has not yet been completely simulated within a capsule. We have checked out his environmental control system in a vacuum tank. We do not yet have a capsule available to check the pilot within this capsule with all the systems. But this is planned to be done in the future.

The Chairman. Suppose a short circuit occurs within one of those 7 miles of wire, would the astronaut be able to move about enough to correct the short circuit?

Mr. Low. Yes. He can reach his entire instrument panel. He would not be able to reach, for example, behind the instrument panel. But he does have a number of fuses on the panel, here, and if a short circuit, for example, should blow a fuse, he would be able to change that fuse.

The Chairman. Put in a new fuse?

Mr. Low. That is right.

The Chairman. But that is as much as he could do in the way of repairs?

Mr. Low. That is right.

The Chairman. Pressing a button is about all he could do?

Mr. Low. Yes.

But I should mention, perhaps, that almost each one of the systems and subsystems within the capsule is duplicated. There are two radio transmitters, two receivers, there are double systems. So that even if one goes out he would still be able to get along on the secondary system.

Mr. Bass. How does he breathe? I gather he does not breathe the air in the capsule?

Mr. Low. Let me go back to the chart showing the capsule again.

You will notice that the pilot is within a pressure suit. Now, the oxygen from the environmental control system can be circulated through his suit and he would then be breathing within the suit only; or he has the option of opening the face plate on the suit in which case he would breathe the oxygen within the capsule.

Mr. Fulton. Of course there is a question that always pops into your mind. He isn't a Senator who can stay on the floor for 20 hours. Where is the bathroom in the capsule? Is there one? [Laughter.]

Mr. Low. No, there is not.

The Chairman. Better take that up in executive session. [Laughter.]

Mr. Fulton. I am worried about the guy.

Mr. McDonough. What is the duration of his flight?

Mr. Low. The flight will be 4½ hours.

Mr. McDonough. Four and a half hours.

Mr. Low. He will be on a low residue diet for some 3 days before the flight.

Mr. McDonough. Going back to the period where he uses the retrorocket to reduce his speed from 17,500 to 350——

Mr. Low. He reduces the speed with the retrorockets only from 17,500 to 17,150, only by 350 miles an hour. Then as he flies back through the air, the drag of the air through which he flies will slow him down to 200 miles an hour.

Mr. McDonough. Then the only other brake he has is a parachute?

Mr. Low. A parachute that comes out only when he is flying at about 200 miles an hour.

Mr. McDonough. Has that been simulated?

Mr. Low. Yes. As you will see in the motion picture we have run through a very extensive series of parachute tests where we have dropped full-scale capsules out of planes time and again to check out the parachute systems.

Mr. McDonough. At 200 miles an hour?

Mr. Low. Yes, sir; this will be shown in the picture.

The Chairman. Suppose the rocket goes up and gets into an orbit of 18,000 miles an hour. I notice the ICBM's have a speed of 18,000 miles an hour. How would you get him out of orbit then?

Mr. Low. By firing these rockets at the proper place and the proper time in orbit, particularly by firing them at the apogee or the highest point, one could still get him out of orbit even if the highest speed in the orbit is 18,000 miles an hour.

Mr. McDonough. Another question, Mr. Chairman.

You say 4½ hours is the duration of the flight. Can he permit a longer duration than that? Can he fly for a longer period than that, if he wants to?

Mr. Low. All systems within the capsule are designed for longer periods of time, but our plan now is that, in the initial stages of flight, we will allow him only to go up for 4½ hours, which amounts to three orbits. The recovery ships will be deployed for this three orbit mission. If he stayed up longer then he might come down in a landing area that is not covered by ships for example.

Mr. McDONOUGH. This is ground control?

Mr. LOW. That is right.

Mr. McDONOUGH. He comes down under a ground control station?

Mr. LOW. He comes down either under ground command or under his own command; both are possible. In case the ground command should fail, he still could get himself out of orbit.

Mr. FULTON. Mr. Chairman.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. On the first space flight, what is the altitude, how far will he go and how long will he be up?

Mr. LOW. Mr. Fulton, with my next two or three charts I am going to cover all of these points, I think, in some detail.

Mr. FULTON. One other thing. There are always rumors getting started. I read an article that a woman may be first in space. Is that wrong? Are you training or recruiting any women for this?

Mr. LOW. I can only speak for this Nation's effort. [Laughter.] We have only the seven astronauts who were introduced to you gentlemen last spring, I believe. We have no additional ones.

Mr. FULTON. I saw a very comely young lady on the front page of one of the large circulation magazines in the United States. It stated that she was being considered.

Mr. McDONOUGH. That was for a newspaper magazine story.

Mr. FULTON. Is it true or not?

Mr. LOW. She is not being considered by us.

The CHAIRMAN. The rumor I heard was that a Congressman was going up.

Mr. MOELLER. I heard he was going to be the chairman of our committee.

Mr. FULTON. I volunteered 2 years ago and was rejected. [Laughter.]

Mr. LOW. During this calendar year we will start a very important series of qualification flights using the Redstone booster.

The Redstone booster is the last one of the three vehicles shown by these models (fig. 156, p. 748).

In these flights the Redstone will accelerate the capsule to a speed of 4,000 miles an hour. It will carry it to an altitude of 125 miles, and to a distance of 200 miles from Cape Canaveral. During the launch, 6½ g's will be sustained 11 g's during reentry, and there will be 5½ minutes of weightless flight along this trajectory.

Now, our plans are to initially fly an instrumented capsule along this type of a trajectory. Later on we will fly chimpanzees along a similar trajectory. And, finally, when we are convinced that all the systems are sufficiently reliable we plan to have manned ballistic flights using this Redstone vehicle.

In these flights man will be subjected to essentially the same forces during exit and reentry as he will be in his orbital flight, and the 5½ minutes of weightless flight which is better than five times more than had heretofore been possible in airplane flights.

We believe that these flights will tell us a lot concerning the astronaut's capabilities in space flight before we finally send them on an orbital mission.

Following the Redstone flights there will be a series of ballistic flights using the Atlas booster (fig. 157, p. 748).

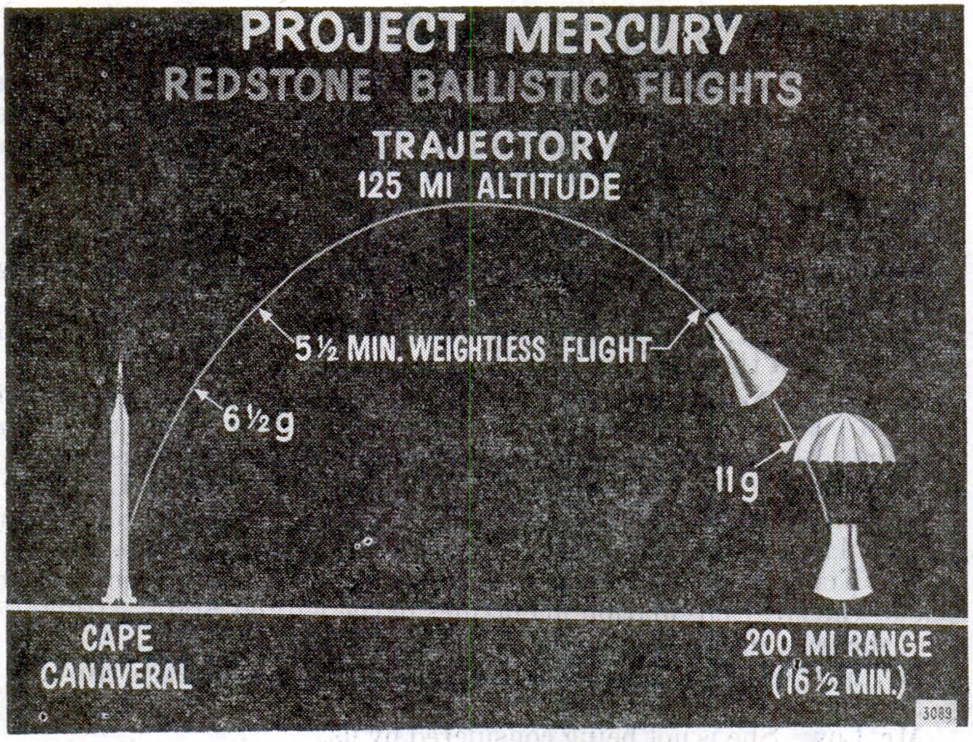


FIGURE 156

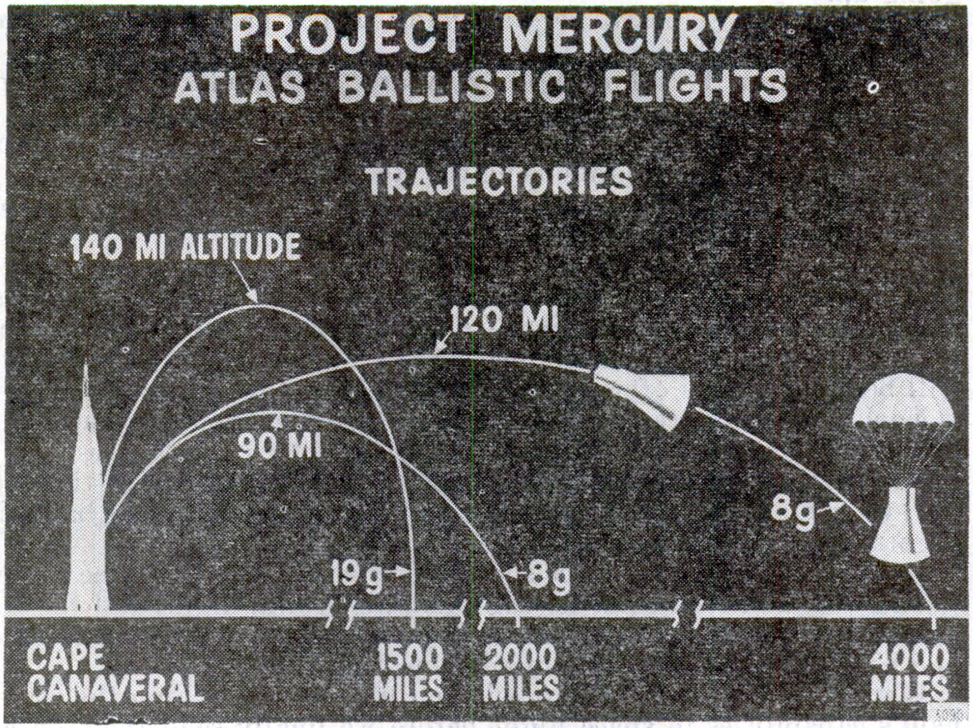
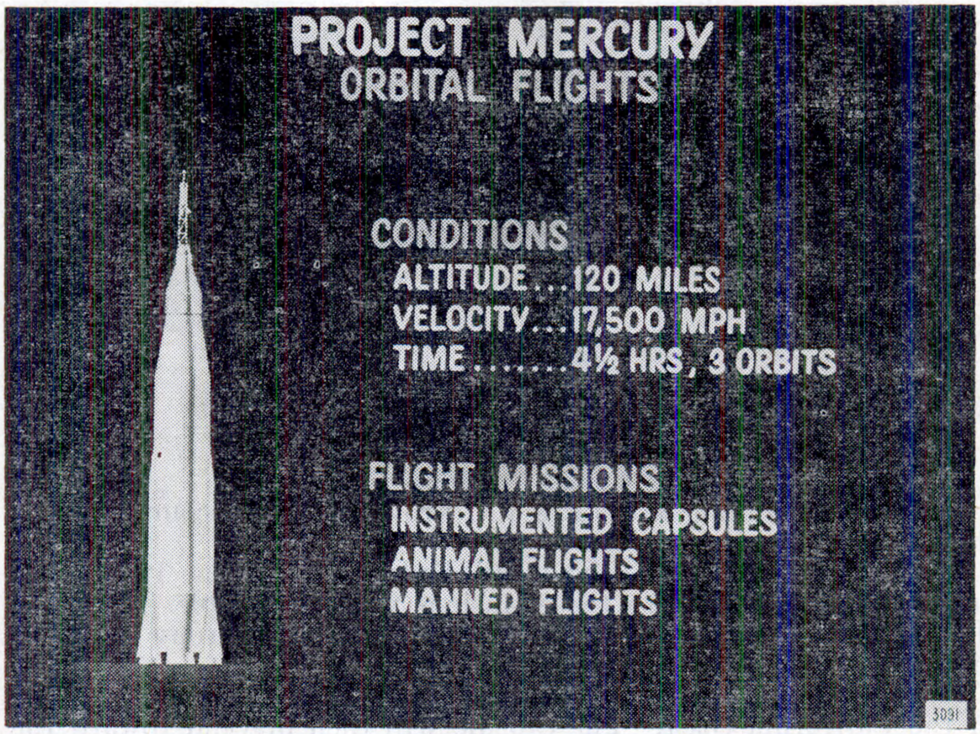


FIGURE 157

All of the Atlas ballistic flights will be unmanned. Without going into a great deal of detail, let me just say that by having three different types of Atlas ballistic flights we will cover all of the forces and heating, and the entire speed range that will finally be encountered in the orbital mission.

In the orbital mission (fig. 158), the Atlas will carry the capsule to an altitude of about 120 miles; the speed in orbit, I mentioned before, will be 17,500 miles an hour. Each orbit will last about 90 minutes. It is planned to keep the capsule aloft for 4½ hours, or three orbits.



PROJECT MERCURY
ORBITAL FLIGHTS

CONDITIONS
ALTITUDE ... 120 MILES
VELOCITY ... 17,500 MPH
TIME .... 4½ HRS, 3 ORBITS

FLIGHT MISSIONS
INSTRUMENTED CAPSULES
ANIMAL FLIGHTS
MANNED FLIGHTS

FIGURE 158

Again, in the orbital missions we will initially have instrumented capsules, later on capsules containing an animal, and finally the manned orbital flight.

The next chart illustrates some of the operational plans for the orbital mission (fig. 158, p. 750).

The launch will be from Cape Canaveral in a direction toward Bermuda. The shaded areas on this map illustrate the planned recovery areas. Ships and airplanes will be deployed in all of these areas in order to pick up the capsule as quickly as possible after it comes down.

The five areas between Cape Canaveral and the African coast are provided for emergency landings. If it is found either on the ground or within the capsule that for some reason it will not be possible to complete at least one orbit, then immediate action will be taken to bring the capsule back down. It would then come down in one of these five areas in the Atlantic Ocean.

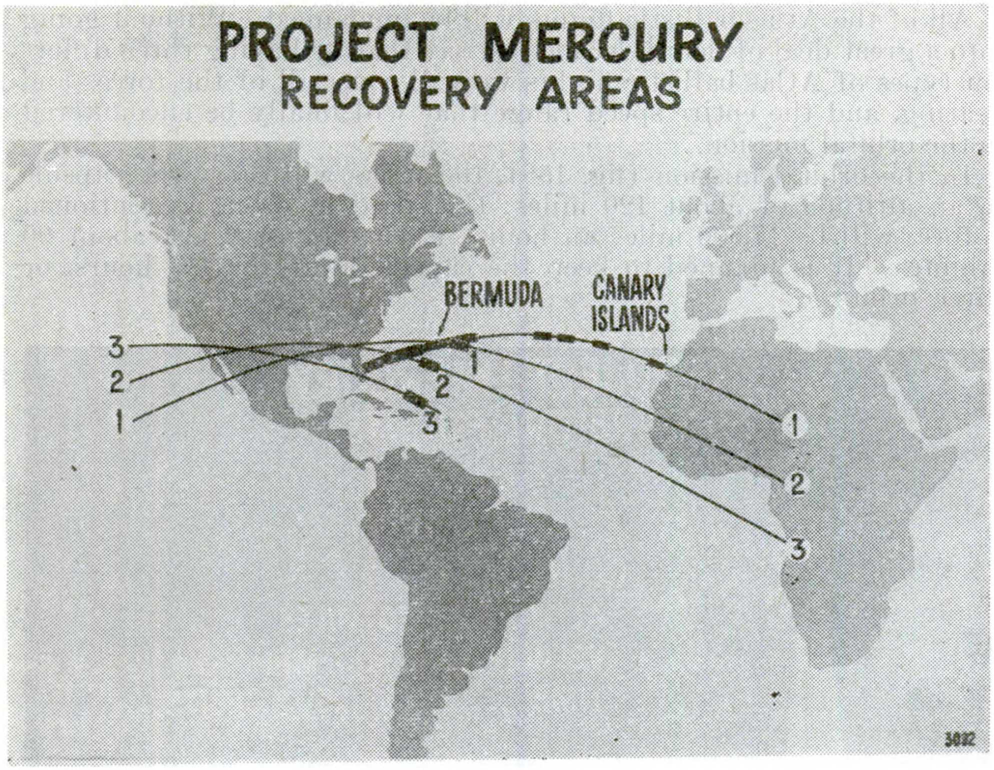


FIGURE 159

Emergency landing areas are also provided at the completion of the first and the second orbit.

While the capsule is in orbit it will be tracked by some 18 stations, and communications with those stations will be possible. I believe that the Mercury tracking network was discussed yesterday by Major Hammond.

At the end of the third orbit the retrorockets will be fired just west of the California coast. The capsule will then descend toward the atmosphere, enter the atmosphere, and land in this area of the Atlantic Ocean. It will then be picked up by waiting ships.

Mr. RIEHLMAN. If the parachute operates properly, at what speed would the capsule be hitting the water?

Mr. LOW. At 30 feet per second or about 20 miles an hour. This speed is the equivalent, I believe, to the speed reached by a man after jumping off a 14-foot wall.

Mr. RIEHLMAN. Then, if the capsule should land on the Earth, it certainly wouldn't be destroyed because of the speed it will be traveling?

Mr. LOW. No, sir.

The CHAIRMAN. At 20 miles an hour, don't you get some air friction?

Mr. LOW. It will land at about 20 miles an hour.

The CHAIRMAN. I mean the orbit?

Mr. LOW. The orbit? In a 120-mile orbit the capsule would not stay aloft indefinitely. There is enough air up there to bring it down in perhaps 4 or 5 days.

The CHAIRMAN. But won't it build up a lot of heat from friction?

Mr. LOW. Not while in orbit. It will only be heated after it reenters the atmosphere at a much lower altitude.

The CHAIRMAN. You assume there is no air at 120 miles?

Mr. LOW. There is so little air up there, and the air is not very dense, so that it cannot heat the capsule very much.

Mr. MOELLER. On the third orbit, as it is coming down, it should be visible over a good share of the United States, should it not?

Mr. LOW. Yes, sir.

My next chart (fig. 160) shows our projected Mercury schedule. First, I have listed the schedule for the Little Joe vehicle, which is a launching vehicle used in the research and development program, the first one of the display models. The first Little Joe flight took place in October 1959. Additional flights were made in November and December 1959, and one in January 1960.

We plan to make at least one more Little Joe flight in the first half of this calendar year.

Redstone flights will start in about the middle of this year, and carry on for approximately 1 year.

The first Atlas ballistic flight took place in September 1959. This flight, again, will be shown in the motion picture. We plan to resume Atlas ballistic flights in about the middle of this year, and after a series of ballistic flights we will then have the instrumented orbital flights, followed by animal orbital flights, and manned orbital flights.

I would now like to show the motion picture which is in three parts.

First, it will show some of the accomplishments in the Mercury research and development program, of the past year. Secondly, there

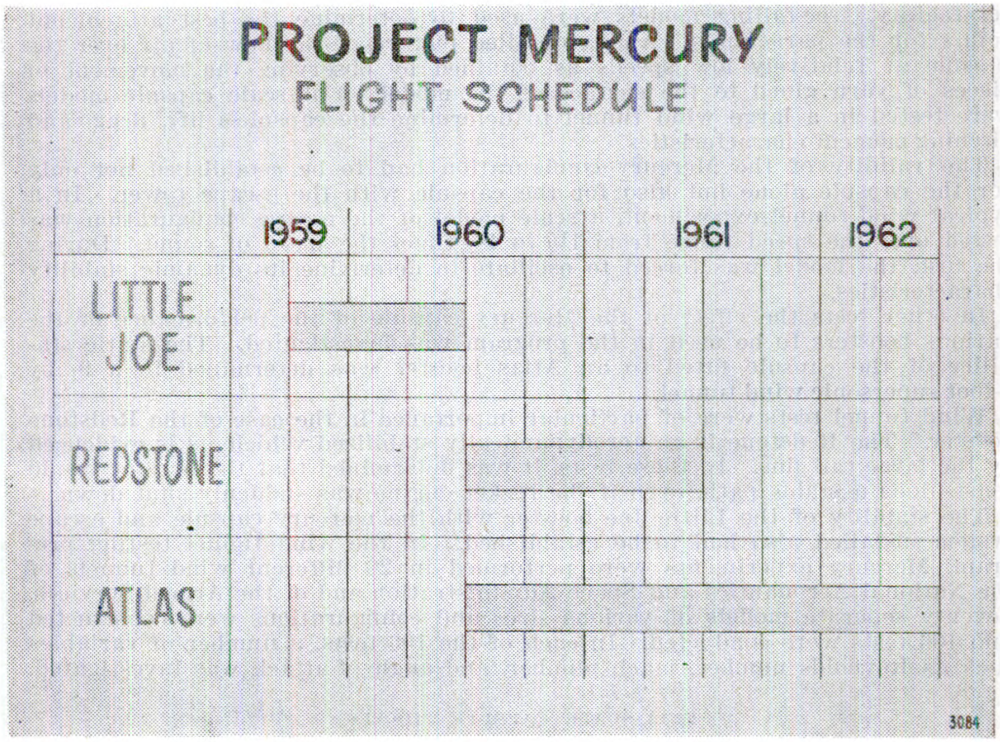


FIGURE 160

will be a few short scenes showing the Mercury astronauts and their training program, and the third part deals with the production of Mercury capsules.

May I now have the motion picture, please.

(A sound motion picture was shown, the sound track of which is as follows:)

FILM REPORT—PROJECT MERCURY, DECEMBER 31, 1959

Project Mercury is the name given to the Nation's manned orbital space flight program being conducted by the National Aeronautics and Space Administration. It involves a continuing broad research program.

WIND TUNNEL TESTING

The Mercury capsule shape was determined from intense scientific and engineering investigations using a wide variety of technical equipment. The moment of inertia on test models was determined on this pendulum rig. Wind tunnel tests of small- and large-scale models have been carried out covering a speed range from zero to 18,000 miles per hour. Small models of the capsule were fired in this supersonic free-flight ballistic gun range. In the gun, helium compressed by a powder charge accelerates the 1-inch model down a 30-foot instrumented range of recording stations. The model achieves speeds of up to 10,000 miles per hour. Data are recorded by means of special cameras located along the length of the range. As the model speeds down the gun range barrel, photographs and shadowgraphs are acquired. This shadowgraph taken at one of the recording stations clearly shows the flow of air passing around the model at supersonic speeds. Detailed analysis of data acquired in tests of this nature provides a solid basis for proceeding to more complex tasks, and to improved version of the capsule shape.

In other tests, a small model was instrumented to measure the scorching heat of reentry as simulated in a shock tunnel. The air in this tunnel rushes past the model at 14 times the speed of sound. The severe heating ionizes the air in the region of the heat shield, causing it to glow. In another wind tunnel facility, free-falling models were used to determine the best attachment points for the parachutes. And a detailed picture of the flow of air over the capsule at relatively low speeds as obtained by observing the movement of pieces of yarn glued to the surface of the model. Full-scale capsule models were tested in a large wind tunnel to determine the capsule's lift, drag, and pitching moment characteristics.

The validity of the Mercury configuration had to be established not only for the capsule alone but also for the capsule with the escape tower. In a typical wind tunnel experiment, a scale model of the escape configuration was tested over the speed range from 1½ to 4½ times the speed of sound. During the test, the model was forced to oscillate to determine its dynamic stability characteristics.

In other tests the effect of the Mercury capsule of the performance of the various boosters to be used in the program was investigated. The static stability of the capsule fitted to an Atlas booster was determined in a 9- by 7-foot supersonic wind tunnel.

Wind tunnel tests were of particular importance in the case of the Redstone booster. The Redstone is an aerodynamically stabilized vehicle as is evidenced by the large tail fins. In these tests, it was determined that the booster would coast along a stable path, even if the rocket engine was suddenly shut down.

The stability of the Little Joe booster with the mercury capsule and escape system installed also had to be established. In the wind tunnel testing program, Mercury experiments were performed in 26 different wind tunnels of the National Aeronautics and Space Administration and of the Armed Services. Seventy separate models of various sizes and configurations were constructed and 106 tests were conducted. In each of the 106 tests, a number of variables such as Reynolds number, mach number, and angle-of-attack was investigated.

FULL-SCALE CAPSULE MODELS

But wind tunnel tests alone are insufficient to solve all of the many problems associated with the Mercury flight system. A flight test program using full-scale models of the Mercury capsule was, therefore, initiated. These boilerplate models, which are made in NASA's shops, duplicate fully both the weight and the external shape of the final Mercury operational capsules. Their construction is greatly simplified through the use of heavy welded sheet metal. They do not include many of the Mercury subsystems, such as the life-support system, or the communications equipment. These boilerplate capsules have been used to develop the parachute system, to validate recovery procedures, project the functioning of the escape system, and to determine the motions and heating of the capsule during reentry.

AIRPLANE DROP TESTS

Large cargo airplanes were used in the development of the parachute system. Full-scale boilerplate capsules were dropped from Air Force C–130 aircraft at high altitudes. The capsule slides out of the plane's cargo door on a sled. As soon as it is clear of the aircraft, the sled is released, and after a period of free fall the lid on the antenna canister is released. Then the small drogue parachute is ejected by a mortar charge. This parachute reduces the capsule's swinging motions in the early stages of the descent. At a predetermined altitude a small parachute pulls the top antenna housing away from the capsule and automatically deploys the main descent parachute. The capsule then descends toward the water. The main descent parachute is a 63-foot ring-sail type cargo parachute. Upon impact on the water, the parachute is released from the capsule by a small explosive charge to avoid dragging the capsule in the wind.

The airplane drop tests also provide an opportunity to exercise the various recovery devices and to further develop and improve recovery operational procedures. After impact, a smoke generator is energized to emit smoke from the top of the capsule to aid the visual search. This is a view of the capsule from an approaching recovery vessel. A green dyemarker solution is released from the base of the capsule to help make it visible from greater distances and altitudes, and the small antenna on top of the capsule transmits signals from the automatic rescue beacons to searching ships and aircraft.

ESCAPE SYSTEM TESTS

Concurrent with the airplane drop tests, an extensive rocket flight test program has been initiated. At the National Aeronautics and Space Administration's launch site at Wallops Island, Virginia, tests were performed to develop the emergency escape system and qualify it for future use on manned flights.

Escape from the launching pad can be simulated by lifting a capsule from the ground with the escape rocket as the only means of propulsion. After ignition the escape rocket burns for only 1 second. It appears to burn much longer here in this slow-motion sequence. In an inflight orbit, the capsule would be carried at least 250 feet away from its booster, during the first second. The capsule and the tower then coast together to the peak of the trajectory. The gentle rotation is caused by a deliberate offset of the rocket thrust to provide a lateral displacement of the capsule as it leaves the booster. This rotation would impose only small loads on the pilot inside the capsule. At a maximum altitude, the tower is separated from the capsule with a small rocket. Then the antenna housing lid is released, and the small drogue parachute is ejected by a mortar charge. After the swinging motions of the capsule have been reduced the drogue parachute and the antenna housing are jettisoned, automatically deploying the main parachute. On impact, the parachute is automatically disengaged from the capsule.

In an off-the-pad abort, the capsule reaches an altitude of more than 2,000 feet. The main parachute was deployed and opened fully about 1,000 feet, providing ample time for the use of the reserve safety parachute if required. In these tests the capsules were recovered by helicopters and returned to Wallops Island for further use in the test program. The tests also provided an opportunity to conduct development work on the recovery and pickup techniques.

LITTLE JOE BOOSTER

Other flight tests are being carried out with a series of booster vehicles of increasing size and capability. The smallest of these is the Little Joe booster. The Little Joe airframe, produced especially for Project Mercury by the North

American Aviation Corp., houses four large Castor solid-fuel rockets and four smaller Recruit rockets. The holes in the base of the vehicle indicate the relative sizes of these rockets. The Little Joe booster is unguided and derives its aerodynamic stability from four large tail fins. One of these fins is shown here as it is being assembled on a special fixture.

Preliminary testing of the completed airframe is accomplished in a static test tower at the North American plant. The use of the Little Joe boosters in the Mercury development program provides an economical means for simulating many of the most severe launch emergency escape and recovery conditions.

Final assembly of the booster takes place at Wallops Island. First the rockets are erected, then the airframe is fitted around them. The capsules used in the early phases of the Little Joe program were manufactured in NASA's shops and do not contain many of the systems and subsystems that will be part of the Mercury operational capsules. The escape tower and rocket, however, are final production hardware, being qualified in the Little Joe program.

In the fall of 1959, three Little Joe vehicles were launched successfully. The first was a test of the basic booster system. In the second test, the escape mechanism was activated intentionally during the early phases of flight. This test simulated a severe escape condition that could occur in an orbital flight launch. The capsule was recovered undamaged shortly after landing. The third flight was used to perform an escape maneuver at high altitude. After a planned escape, the capsule coasted to an altitude of 55 miles and was recovered 200 miles from the launch site. On this flight, a small monkey was within the capsule and was recovered alive and well at the end of the flight.

Before the firing the scaffolding is removed and the booster is supported on a simple launcher. On takeoff, two of the Castors and four Recruits are ignited, giving a thrust of one fourth million pounds. The smaller Recruits burn for only 1 second, while the Castors have a burning time of 27 seconds. The second pair of Castors will be ignited just before burnout of the first pair, but at an altitude too high to be visible from the ground. The remarkable stability of the Little Joe booster is well demonstrated in this flight. Later on in the flight, the escape rocket is ignited, separating the capsule from the booster.

At the completion of the escape sequence, the capsule falls back toward the ocean and parachutes are deployed. Recovery is accomplished by Navy ships. After recovery the capsule is hoisted on board with a special net-like device and returned to NASA facilities for visual inspection and for an analysis of the data recorded during the flight.

BIG JOE FLIGHT

The Atlas booster was used in the most severe test of the Mercury system that has been performed to date. In that test, a research and development version of the capsule was launched from Cape Canaveral, Fla. In contrast to the Little Joe vehicle, the combination of the developmental Mercury capsule with the Atlas booster was nicknamed Big Joe.

The trajectory for this flight was shaped to simulate a return from orbit without actually going into a satellite orbit. The objectives of the Big Joe test were to check the capsule's heat protection at nearly orbital speed; to verify its aerodynamic stability; to provide a severe test of the onboard recovery system; and to develop recovery procedures in a realistic test situation.

The Big Joe capsule was taken to the launching pad several days prior to the shot. Within the capsule is special instrumentation to measure the loads, noise, motions, and temperatures during flight, and a control system to orient it into the proper attitude after its separation from the booster.

As the capsule is hoisted to the top of the gantry, the plastic heat shield, designed to dissipate the tremendous heat of reentry, is clearly visible. The capsule is mated to the top of the Atlas booster and attached with a special clamp. The clamp will be released explosively after the Atlas engines are shut down. The special Mercury capsule used in this test was not fitted with an emergency escape system.

The booster and capsule systems and their instrumentation were checked and rechecked during the days prior to launch. A joint Defense Department Recovery Task Force was deployed along the capsule's intended flight path. The launch was made in the early morning hours so that a full day would be available for the recovery operations if required.

In the blockhouse, the countdown proceeds for many hours before the firing. Here the functioning and readiness of thousands of component parts of both the booster and the capsule are recorded. The malfunction of any one of these parts could make the difference between a successful flight and a complete failure.

Minutes before the firing, liquid oxygen is piped into the booster which is now ready for flight. As the countdown approaches zero, the final switch is closed and Big Joe is launched. This Atlas booster carried the capsule to an altitude of 100 miles and to nearly orbital speed. The Big Joe capsule was then separated under conditions that closely simulated orbital reentry. On the recovery ships the capsule appeared as a flaming fireball as it streaked back into the atmosphere. Many hundreds of miles from Cape Canaveral, airplanes vectored to the impact area and soon picked up the capsule's recovery signals. Two destroyers raced to the area and sighted the capsule about 8 hours after launch. The capsule was picked up by the destroyer *Strong* and returned for a detailed inspection and for an analysis of recorded data. It had survived its reentry in excellent condition.

The recovered Big Joe capsule represents a major milestone in Project Mercury in that it positively demonstrated the validity of the Mercury design concept.

MERCURY ASTRONAUTS

Early in 1959, a team of seven engineer test pilots was selected for Project Mercury: M. Scott Carpenter, L. Gordon Cooper, John H. Glenn, Virgil I. Grisson, Walter M. Schirra, Alan B. Shepard, and Donald K. Slayton.

Following their selection, the men reported for duty with NASA's Space Task Group at Langley Field, Va. Their training, which has been in progress since April 27, 1959, includes both academic classroom instruction and practical experience in training devices across the country. The academic program includes instruction in the basic sciences related to space flight, astronautics with detailed studies of propulsion systems, electronic systems, guidance, trajectories, and other technical aspects of rocket training.

In addition to a penetrating study of physiology of flight, the astronauts are being educated in the basic skills required to make scientific observations during orbital flight.

SUPPORTING COUCH

As the training program progresses, the development and production of special flight equipment has continued. Each astronaut has been fitted with a custom-made couch developed to support his entire body and reduce the physiological effect of high acceleration forces or g's. To make the couch, the astronaut is placed in a bed of quick-hardening sand. After the sand is carefully packed around the astronaut's body, carbon dioxide is applied to speed up the hardening process. At the end of the 2-hour long couch molding process, the astronaut is carefully lifted out of the mold. These Mercury couches were produced at NASA facilities with painstaking care to assure proper fit and effectiveness in protecting the pilot during flight.

HEAT INDOCTRINATION

During reentry into the Earth's atmosphere, the Mercury capsule will be subjected to intense frictional heat. One of the early practical training activities for the astronauts provided familiarization with high heat conditions and the ability of the ventilated full-pressure suit to keep them cool under these conditions. This heat chamber is capable of producting the same temperatures anticipated inside the capsule during the reentry from orbit. Quartz tubes along the outer walls provide the chamber with heat. In this test, the pressure suit ventilation system was turned off to familiarize the astronaut with his own physiological reaction to short periods of high heat.

FLIGHT SIMULATORS

In Project Mercury, the pilot will play an active role in the operation of the Mercury satellite. He will be able to control the capsule's attitude. He can maintain current knowledge of his position visually and through the use of radionavigational aids. He will be able to operate all primary flight controls, such as the firing of the retrorockets to begin his descent toward the atmosphere and to deploy the parachutes once he has reentered the atmosphere. Wherever possible, the capsule's flight performance is simulated on the ground to provide realistic economical training for the astronaut.

In this fixed-seat analog simulator, instrument readings indicating a simulated capsule attitude are supplied by an analog computer. The pilot responds to the instrument readings by applying the proper control movements with the sidearm controller. In flight, this controller would activate small reaction jets to turn the capsule about its three primary axes. On the simulator, the control movements feed signals to a computer and result in changed instrument readings portraying the capsule attitude changes which would have resulted from control movements in flight. Training on such simulators, the astronaut develops skill in maintaining the capsule's orientation during orbit, retrofire, and reentry.

Following the indoctrination on the fixed-seat static simulator, the pilots will be trained on a cynamic simulator. On this device, the astronaut will be supported in a molded coach. His sidearm controller will be connected to a system of reaction jets similar to the ones in the Mercury capsule. These jets will rotate the coach, or pitch it up, down, or sideways. An intricate system of motion picture displays will give a view similar to that seen by the pilot in orbital flight. A special feature of this simulator is a low-friction air bearing, designed to permit movement in all directions around a center post.

CENTRIFUGE TRAINING

One of the most important phases of the preflight training is that received on the centrifuges at the Wright Air Development Center and at the Aviation Medical Acceleration Laboratory at Johnsville, Pa. These centrifuges have the capability for reproducing the same acceleration or g-forces on the same time scale as will be encountered during the rocket-boosted launch and the reentry into the Earth's atmosphere. In this training, the astronaut learns more about the effect of these g-forces on his ability to perform his inflight functions and what he can do to overcome those forces.

While whirling around in the centrifuge cab, they learn new techniques of breathing and straining, so that they can tolerate these high g-forces while still performing functional control tasks. The centrifuge is operated in response to signals provided by a computer. The sidearm controller also gives electrical signals to the computer. These signals are translated into motions the reaction jets would have given to the Mercury capsule in flight. These signals result in changes in g-forces within the centrifuge cab comparable to those encountered in actual flight. The test demonstrated that a properly trained man in good physical condition would be able to control the Mercury capsule even while being subjected to the high g-forces of launch or reentry.

In other procedural trainers, the astronaut will be checked out completely and repeatedly in all of the procedures in operation of the capsule.

CAPSULE CONTRACTOR

In January 1959, the McDonnell Corp. was selected as the prime contractor to design and construct the Mercury capsules. The selection was based on industrywide competition. In the course of this competition, 12 firms submitted proposals based on NASA specifications for the capsule. After a thorough evaluation of these proposals, a contract was awarded to McDonnell.

An engineering mockup of the capsule was completed by McDonnell in March of 1959. The mockup was complete in every detail, including the escape tower and rocket, the antenna housing, the parachute container, the capsule proper, and the adapter ring that connects the capsule to its booster. The mockup also included cockpit equipment and control layouts. Engineers and officials from NASA met with contractor personnel to assure that specifications governing the capsule's design and the installation of equipment and components were complied with. Special attention was paid to the pilot-support system and to the type and location of pilot displays.

After the mockup inspection had been completed, an official mockup board consisting of NASA officials and military and aeromedical advisers made final recommendations.

The Mercury astronaut trainees visited McDonnell shortly after they reported for duty. All engineers, these men are making a positive contribution to the design of the capsule and determine that all of the capsule systems are compatible with manned operation. Working with the mockup, the astronauts review the pilot displays and check on the accessibility of controls, supplies, and emergency equipment. The location of windows and the ease of entry and exit through the main and emergency hatches was also studied by these men.

CAPSULE CONSTRUCTION

Construction of the capsule was started immediately. Special welding techniques were developed. An argon atmosphere fusion welding machine is used in the fabrication of the thin titanium pressure vessel. The shell is carried past a circular electrode by rotation of a fixture. The pressure vessel consists of a smooth inner skin and a beaded outer skin. Each of these is only ten-thousandths of an inch thick. After the two skins are welded together, stringers, window and door frames, and bulkhead rings are installed. An additional skin will be attached to the stringers.

COMPONENTS AND SUBSYSTEMS

Many of the component parts of the capsule are made by subcontractors under McDonnell supervision. The all-important heat shield is manufactured by the Cincinnati Testing Laboratories. This ablation-type shield is made to the same specifications as the one that survived the Big Joe reentry. During reentry its surface will char and slowly burn away. Through this ablative action the heat of reentry will be dissipated.

Other major subcontractor items are the life-support system, the attitude control system, the horizon scanner, the escape and retrorocket systems, parachute landing system, batteries, and the navigation periscope.

The periscope, which is shown in this sequence, is manufactured by the Perkin-Elmer Corp. With the aid of this periscope, the pilot will be able to perform the functions of attitude stabilization and control and fire his retrorockets even if all of his automatic systems should fail. He will be able to determine his attitude, his orbital track, and the ellipticity of the orbit. Once he has made a precise determination of all of the orbital elements he will be in a position to fire the retrorockets at the proper instant so that he will land in a prescribed recovery area.

GROUND SUPPORT EQUIPMENT

An operation as complex as that of putting man into space requires a great deal of ground support equipment. The equipment for this ground support is being developed by McDonnell and its subcontractors.

A typical example of this type of ground support equipment is the array of electronic instruments to be used in the checkout of the capsule's communications gear. Once the capsule is in orbit, the pilot will rely completely on his various channels of communication, such as the radio voice transmitters and receivers, and the various tracking and rescue beacons. His actions will be monitored by other communications channels and certain capsule functions will be commanded from the ground.

The proper functioning of all of this equipment can be guaranteed only by checking it in every detail during the days, the hours, and the minutes before launch. Similar equipment is being fabricated to check all of the other capsule systems on the ground and to monitor their functions during flight.

The ground support equipment will be installed in a number of trailers so it can be transported to the launching site and utilized in several different locations.

Because both Redstone- and Atlas-launched Mercury flights will take place concurrently, some of the equipment must be duplicated. Two of the trailers shown here will house checkout equipment, while telemetry receiving equipment will be installed in two more. A fifth trailer will contain spare parts.

CAPSULE ASSEMBLY

In the fall of 1959, many of the capsule components reached the final assembly stage. The housing for the three retrorockets is equipped with a shield and with insulation to maintain the rockets at the proper temperature and to protect them from meteorite damage. A number of the top antenna canisters have been manufactured and are ready for the installation of their electronic components. Several of the escape system towers have been assembled and prepared for shipment. Some of these have been flight tested in the off-the-pad abort and Little Joe experiments conducted at Wallops Island.

Final fabrication of a number of capsules is well underway. On the production line at the McDonnell plant, several capsules are in various stages of construction. On this line, the pressure vessel is fitted with the upper and lower pressure bulkheads. A large number of brackets and fixtures is installed for the support of the capsule's subsystems, the wiring, the reaction control fuel

lines. At the top of the capsule, the emergency exist hatch is visible. Windows and entry hatch are located along the sides of the shell.

After the capsule fabrication is completed, the various subsystems will be installed. The assembled capsule will then be subjected to an intensive environmental testing program. The entire system must be able to withstand extreme heat and cold, high pressure and vacuum, vibration and noise, and high accelerations. All of these tests will be performed on the ground before the capsule will be certified as being ready for flight.

Project Mercury, the Nation's manned orbital space flight program, is a continuing program of concurrent efforts in research, development, engineering, manufacturing, test, and training, all aimed at the focal point of successful manned space flight at the earliest possible time.

The CHAIRMAN. That is very fine.

Mr. LOW. I have just one more chart (fig. 161). We have attempted to illustrate with the motion picture some of the difficult tasks that confront us in a project of this magnitude. The funds required to carry out this program are listed on this last chart. The major expenditures are for the procurement of boosters and the capsules, themselves; for fiscal year 1961 we are requesting $107,750,000 to carry on this project.

Thank you.

The CHAIRMAN. Thank you very much.

Now, is there anything more for this afternoon?

Mr. SISK. Could I ask just a question before he goes?

The CHAIRMAN. Surely.

Mr. SISK. How much has actually been expended on the project for 1960? Does that indicate it?

Mr. LOW. For 1960 our allocation was almost $75 million.

Mr. SISK. Is that all programed now? Will it all be spent by the 1st of July?

MANNED SPACE FLIGHT

COSTS (IN MILLIONS)

ADVANCED TECHNICAL DEVELOPMENTS	FY 1960	FY 1960 SUPPLEMENTARY	FY 1961
BIOLOGICAL AND HUMAN ENGINEERING STUDIES	2.18		2.09
MERCURY DEVELOPMENT PROGRAM	5.27		4.05
ADVANCED RE-ENTRY CONFIGURATIONS	.10		1.00
FLIGHT RESEARCH PROGRAM			
MAJOR BOOSTERS	23.46		25.65
MERCURY CAPSULES AND SUPPORT EQUIPMENT	35.01	12.00	35.29
TRACKING NETWORK AND RECOVERY OPERATIONS	8.94		39.67
	$ 74.96	$ 12.00	$ 107.75

5009

FIGURE 161

Mr. Low. Yes, sir, it will all be obligated before July. In fact, we are requesting a supplemental of $12 million in 1960.

Mr. Sisk. That was really the reason for my question. I did not understand that you were asking for a supplemental on this. I understand there is a $23 million supplemental for the Saturn.

Mr. Low. No, sir, this $12 million is part of the $23 million supplemental.

Mr. Sisk. I see.

Mr. Low. And the funds included in the supplemental were authorized last year but not appropriated.

Mr. Sisk. But not appropriated. So actually you expect to need and to actually spend in fiscal 1960 about $86 million or $87 million?

Mr. Low. $87 million; that is right.

Mr. Sisk. And you propose $107 million. I was just trying to get a comparison.

Mr. Low. Yes, sir.

Mr. Bass. Mr. Chairman.

The Chairman. Yes, sir.

Mr. Bass. While the pilot is in flight, I gather he will not use the manual controls unless the automatic controls fail?

Mr. Low. He does not have to use them unless the automatic controls fail. But since the major objective of the project is to determine the pilot's capabilities in flight, certainly we expect him to try to use the manual controls to show us how capable he is of performing various tasks in space flight.

Mr. Bass. When he actually goes into orbit, is he going to exercise his own judgment as to whether he will use the manual controls?

Mr. Low. Yes, sir.

The Chairman. Any further questions?

Mr. McDonough. When do you anticipate the first manned flight?

Mr. Low. The first manned orbital flight?

Mr. McDonough. Yes.

Mr. Low. Hopefully, within 2 years, but I should mention that all we can predict today are target dates. We don't know—we have not yet flown a production capsule. We are moving a tremendous step forward with this program; we are increasing the speed, for example, of manned flight to a factor of almost 10, the altitude by a factor of almost 5. We don't know what difficulties we are going to encounter as we carry the program down the road, so that any dates we predict now must be considered only as target dates. They may be changed as we go further on.

Mr. McDonough. If you do arrive at a manned flight in 2 years, you will pick one of the seven astronauts that are being trained?

(Mr. Low nods.)

Mr. McDonough. And if the first flight is successful, then out of the other six remaining will be the next man. Is that the program?

Mr. Low. Presumably so.

Mr. McDonough. Thank you.

Mr. Sisk. Is the gentleman finished?

Mr. McDonough. Yes.

Mr. Sisk. Mr. Chairman, could I just ask him this? Maybe it is not a good question, but is the only reason why we are proposing to send only one man to start with a matter of weight, strictly a matter of thrust? My colleague, Mr. Fulton, touched on some of the magazine articles we read. I am sure we all read the various rocket magazines. The idea was proposed in an article recently that perhaps it would be better for two people to make the flight, taking into consideration the psychological problem that would be involved in making a flight of a longer duration than four and a half hours. I am just curious if that was the only consideration, this matter of weight, that one man goes instead of two.

Mr. Low. It certainly is the most important consideration. As long as we are tied to the Atlas booster, and until the Saturn or bigger launching vehicles come along, we are limited in weight, and we have all we can do to get a one-man capsule into orbit.

Mr. SISK. That has been my understanding all the way through. The theory of this particular individual in his article was that companionship was needed to overcome the great loneliness that comes in a flight of this type.

The CHAIRMAN. Any further questions? Mr. Hechler?

Mr. HECHLER. Mr. Low, have you seen the committee's staff report on Project Mercury?

Mr. Low. Yes, sir, I have.

Mr. HECHLER. There is a statement in the report that—

> in official announcements NASA has wisely refused to commit itself to any time schedule which might bring a temptation to launch a man before the level of development fully justified the step.

I was a little afraid in your answering my colleague maybe you were starting to pin this down. I think this is a wise doctrine stated in our committee report.

Mr. Low. I tried to make the point that we cannot really pin it down because we don't know yet.

Mr. HECHLER. This Mercury project has a tremendous psychological value from an international standpoint, would you agree?

Mr. Low. Yes, sir.

Mr. HECHLER. And I am just wondering, would you say that this is the primary value of it?

Mr. Low. No, I don't think so. We are certainly moving along in this project as quickly as we possibly can. We have as one of our objectives to do this mission at an early date. But beyond that we must accomplish manned space flight because our entire space flight effort is hinged on the belief that man will be part of it, not only in Mercury, but in many future missions. And we must, therefore, determine at a very early date exactly what man will be able to do, what he will be capable of doing, so that we can then go on to the next steps.

Mr. HECHLER. The reason I asked this was I wanted to ask specifically what scientific value will accrue from this as opposed to later space flights, perhaps, of greater distances with larger boosters that might be designed to produce greater scientific results. I had a feeling that perhaps there was an element of psychological prestige involved here which was far outweighting the scientific value. I just wanted to get your comment.

Mr. Low. There is certainly some of both involved. But I do very strongly believe that there is a definite need to learn about man's capabilities in the space environment, and Mercury was designed to give us those answers.

Mr. HECHLER. One of the reasons I am asking these questions is to try to see if we can learn from the lesson of Vanguard and not give Mercury the kind of tremendous advance buildup that might result in a letdown if things should develop that we happen to be second in space. Russia, after all, has demonstrated in putting a dog into flight and by other means, through the use of her large boosters, that she may have the capability of putting a man up there before we do. If we stake so much prestige on this, isn't this running us into a little international danger?

Mr. LOW. Well, this is precisely why I am trying to make the point that, yes, we would like to be first, but even if we are not, this is still an important first step in our manned exploration of space.

Mr. HECHLER. One final question, which relates to the funding. Because of the extreme importance of this, I am sure other members of the committee also are deeply concerned that the program is adequately funded. Are you personally satisfied that the program is adequately funded?

Mr. LOW. Yes, sir, I am, provided we can get our supplemental approved; the funds we have requested are adequate funding for the Mercury program.

The CHAIRMAN. We have a job to do to help NASA get its supplemental.

Mr. HECHLER. Mr. Horner indicated he might want to add to that.

Mr. HORNER. To the funding question?

Mr. HECHLER. Well, any other comments?

Mr. HORNER. I had shaken my head at your suggestion that the primary purpose of the project Mercury was one of national prestige and psychological advantage. We are not approaching the project in that manner. The primary purpose is to determine the feasibility and the utility of manned space flight, and this in fact is a prerequisite for most of our follow-on space program.

You will recall from our 10-year plan that one of the major objectives in the latter part of the decade, for example, was manned circumlunar navigation. Now, clearly we cannot take on that kind of an objective until we determine for ourselves whether manned space flight is practical. We have approached project Mercury using the simplest, most reliable and, therefore, you might say the earliest method of determining whether or not manned space flight is practical in terms of its feasibility, in terms of the utility of a man in space.

You asked, also, the question: What was the scientific product of this?

Well, contrary to many of our other experiments, perhaps most of the scientific product of this project is going to be in the life sciences area, rather than in the physical sciences area, and it is different in that respect; but it is extremely important that we have these life sciences returns if we are going to carry on with the manned space program.

Mr. HECHLER. Thank you, Mr. Horner.

The CHAIRMAN. We certainly thank you, sir. If there is no further business we will adjourn until tomorrow morning at 10 o'clock.

(Whereupon, at 4:32 p.m., the committee adjourned, to reconvene at 10 a.m., Wednesday, February 17, 1960.)