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Notes from PSAC Space Science Panel Meeting April 15-16, 1960

Introductory remarks were made by Dr. Purcell, Chairman of the Panel, concerning the interest that the Panel had in the Rover and Big Booster programs and how they were related. The first presentation was made by Dr. Schreiber from Los Alamos on Rover.

First he gave a brief history of the program. So far all they have done is run one graphite heat exchanger reactor type called Kiwi-A. It has approximately a 14-year history of development, and the reason it is being used right now is that it has a better specific impulse than the chemical type. Some more advanced types using tungsten or carbide are the only ones which approach the efficiency of graphite, but these are not anywhere near ready to be applied. The performance figures submitted by Dr. Schreiber on what can be done with the graphite type reactor are attached. These performance figures he gave out are system studies and they should be used with caution, and the question, of course, remains whether this type reactor can be increased to say 400,000 to 700,000 lbs. thrust.

One possible application of the Rover type reactor would be for a 3rd stage on Saturn. This may be highly preferable to the present planned chemical 3rd and 4th stages.

Kiwi-A cannot lift its own weight but during the experiment they attempted to duplicate the temperature conditions and to deliver 70 megawatts of power

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for a five minute run. At this time Dr. Schreiber showed movies of the Kiwi-A test. During the test a failure in part of the internal mechanism allowed a considerably higher temperature to be reached than had been anticipated. However, the test was essentially a success. Kiwi-A Prime is now being assembled. It was brought to cool critical last week, and plans are to test it in Nevada in June. Kiwi-A-3 will follow in about two months, and the main difference in Kiwi-A Prime and Kiwi-A-3 with Kiwi-A is primarily in the coating of the holes in the graphite. Kiwi-B-1 will be hydrogen cooled nozzle. It will have a factor of 10 greater in power than the Kiwi-A series. It will use liquid hydrogen rather than gaseous hydrogen, and it is to be tested in the last half of 1961. One thing that will delay the testing is that it requires a new test cell to be constructed. Kiwi-B-2 will follow by another 6 months. The primary difference here is that Kiwi-B-2 will use pneumatic control rod actuators which do not require shielding as do the hydraulic type in Kiwi-B-1.

Discussion of Radiation Problems

First we have to define a basic power cycle, which is one begawatt for 5 minutes. Now, if a complete collapse occurred, only 3% of the available radioactivity is released. If the whole reactor is submerged in water even less radioactivity is released. Using the basic power cycle it is possible to runn 10,000 tests in a year and just compensate for the 2% decay in the biosphere.

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Note this assumes that each atom that fissions is dispersed in the atmosphere.

During the Kiwi-A tests pieces of apparatus adjacent to the reactor suffered no radiation damage. However, the reactor cannot be approached immediately after shutdown. For ground tests of this type reactor contamination is not serious if an isolated spot, i. e., 4 miles in diameter, can be used. On a launching pad contamination problems would exist, but probably protection similar to that now being made for explosive reasons would be satisfactory to contain the radiation danger. Some consideration has been given to possible tankage schemes for using a reactor with a rocket. It is stated that the radiation zone from the reactor would only affect tanks of the liquid hydrogen of a small percentage on the end nearest to the reactor. It would not in any way prevent the normal functioning of the pumping system. If the tanks were used to separate the payload from the reactor, the liquid hydrogen acts as a natural shield to protect the payload from the radiation of the reactor. If the payload were to include people, some additional shielding would have to be provided to prevent back scatter radiation.

Higher Temperature Fuel Elements

If they can use 50% zirconium graphite and 50% uranium carbide the weight would be reduced by a factor of 3. Other metallic materials such as tungsten are being investigated for high temperature fuel elements. They are also planning to see how far they can push the graphite type by getting a higher percentage of graphite in the construction of the reactor.

More Advanced Type Reactor

One new type being considered is a fluidized bed. In this some form of basket would probably have to be devised to hold the fluid in place, perhaps using centrifugal force. As yet no practical system has been devised for this.

A second type would be the gaseous reactor. In this case a way must be found to separate uranium and hydrogen in the gaseous stage at a very rapid rate. It is not known how this would work either.

Following this some discussion was held on various phases of the presentation. One question was raised concering the development of pumping equipment. Apparently the only problem different from the development of pumps for conventional chemical rockets is that the pump must be able to work near the reactor in the presence of some radiation.

The second question came up on the difference in rockets and aircraft application of nuclear propulsion. The primary difference is that the rocket is short-lived and uses hydrogen only whereas the aircraft must use air, for example nuclear ram jet operations.

It was discussed how soon this reactor or a similar type might be applicable to an actual rocket. It was stated that NASA and AEC would probably await experience with the liquid hydrogen in late 1961 before making definite plans. This would lead to a probable flight test of the nuclear rocket system

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about 1965. There apparently is no problem in shut-down or re-start of the reactor rocket engine so long as the shut-down is programmed to control the rate of cooling down of the reactor. One problem existing in an interplanetary type mission would be to vent the fuel tanks during the coast periods due to the heating. A question was asked whether there is a difference in a rocket reactor for a single stage type rocket from that to be used for moving out of a stabilized orbit. Apparently they are essentially the same. Another question was brought up as to whether some parallel approach should be made to nuclear rocket propulsion such as the ion propulsion. It was apparently felt by the AEC people that no parallel program should be made but that emphasis should be placed on developing materials, higher temperature fuel elements and more advanced types of reactors. During lunch it was brought out that no large electrical power supplies are being developed for the massive payloads to be carried in the 5 to 10 year period.

In the afternoon Abe Hyatt of NASA gave his presentation concerning the large booster program. In view of the fact that most of the members of the Panel were familiar with the Atlas and Thor combination programs, the first missile he discussed was the Centaur. This missile has a first stage that is a modified Atlas. The second stage is a liquid oxygen-liquid hydrogen consisting of two engines each having 15,000 lbs. thrust being developed by Pratt & Whitney. It will put 8500 lbs. in a 300 n.m. orbit, 1450 lb. payload in a planetary probe, or it will put 915 lbs. in a 24-hour communications orbit. It is scheduled for first launching in mid-1961. The biggest problem on this missile at the present time is to be able to pump the fuel after a coasting period. The second missile described was the Saturn. This program has apparently been divided into 3 missiles, C-1, C-2 and C-3. The C-1 is the only one that has been actually authorized to be built. This first stage consists of 8 Atlas booster engines using liquid oxygen and RP-1 fuel. The second stage has 4 Pratt & Whitney liquid oxygen-liquid hydrogen engines. The third stage is basically the second stage of the Centaur. The C-1 will put 28,500 lbs. in a 300 n.m. orbit, 5,000 in a 24 hour orbit, or 9,000 lbs. in escape. It could land 3,000 lbs. soft shot on the moon. Its first launching is scheduled for early 1964. This will actually be the 11th firing of the C-1. During this period of 11 firings, various combinations of actual and dummy stages will be used. On the first stage an interesting constructional detail is that the fuel part of the tank goes to all of the engines. In this way when an engine develops troubles, it can be shut off and the Saturn will still work, thus giving it a 90% reliability.

The C-2 is essentially the same as the C-1; however, a second stage has been added which consists of two of the 150-200,000 lbs. engines.

In the C-3 the first stage has now been increased in thrust, the second stage now contains 4 of the 150-200,000 lbs. thrust engines, and the second stage of the C-2 has become the third stage of the C-3.

The next missile discussed was the Nova. The only thing that has actually been authorized for this rocket is the engine. This is the 1 1/2 million lbs.

thrust engine. The first stage of this rocket has 6 engines, a total thrust of 9 million lbs., using liquid oxygen and RP fuel. The second stage, indefinite, will be liquid and RP, and will develop 1.8 million lbs. thrust. The third stage, also indefinite, will deliver 600,000 lbs. The Nova will put 270,000 lbs. in a 300 n.m. orbit, or 60,000 lbs. in the 24 hr. orbit, or it will put 100,000 lbs. in a planetary probe.

At this point in the presentation some discussion was made of possible missions for the various big boosters. If 9 Saturn's were used in a rendezvous method, each of the latter to refuel the first one, a soft lunar landing could be made with 10,000 lbs. payload brought back. A six stage Nova will all chemical fuel could also do the same. Four and five stage combinations of Nova and various chemical or nuclear stages could also do the same. An optimistic estimate of the first nuclear type would be 1965, which agrees with the figure previously given by the AEC people.

Considerable discussion followed then concerning what we might use Saturn for. It must be realized at this point, however, that Hyatt is concerned with the launch vehicles and not with the missiles themselves.

First, Saturn can be used for manned exploration (earth orbits)

Second, Possible Venus or Mars probes (unmanned)

Third, Soft shot of requipment on the moon

By this time it is assumed that soft landing on the moon of instrumented payloads would have been made by the Atlas Agena B and Centaur. The discussion that followdd brought out the suggestion that during the Saturn development shots the dummy stages could be used for simple experiments, for example the gravity clock using lead balls.

The question came up as to how a man could be protected against solar emissions of the Winkler type. Dr. Rossi felt these could be shielded against relatively easily because most are below 100 mev. At the question, what means of guidance are being used on the big boosters, it appears that inertial guidance using gyros is generally relied on at the present, although some study is being made of using photo cells focused on the stars.

A request was made for some description of the Scout vehicle. It is to be a four stage vehicle primarily for doing standard scientific experimental shots. The first stage is an Algol solid rocket, the second stage is a Castor solid rocket, the third stage is an Antares solid rocket, and the fourth stage is an Altair solid rocket. The Scout will put 200 lbs. in a 300 n.m. orbit, 50 lbs. in a vertical probe to an altitude of 12,000 miles. The first complete test is scheduled for May.

In summary, Hyatt said that NASA expects to have five generally operational vehicles during the cedade 1960-70. These are:

(1) Scout

(2) Thor Agena B, Atlas or Atlas Agena B

(3) Centaur

(4) Saturn

(5) Nova

Saturday Session

The Saturday meeting was opened with a discussion by Dr. Berkner concerning the problem that had come up on the Needles Experiment. Dr. Berkner reported that the experiment as now proposed is acceptable but that larger follow-up experiments might cause considerable interference with radio astronomy. A committee of the Space Science Board, headed by Dr. Porter, recommended that the whole project be declassified and that it be publicized as a scientific experiment. He wants to declassify the experiment part of it but keep the classification of the project. He also recommends transfer from the DOD to NASA because it is really a passive communications experiment, and that it probably should be used in some way, for example bouncing TV. It was strongly recommended that it not be used to bounce, for example, a picture of the President just before the Summit for fear that the propaganda effect would backfire. It was also strongly recommended that the numbers concerning this experiment be given out as an IRE paper or a paper at an International Scientific Meeting. A parallel paper to the one presented to the Space Science Board by Porter's committee is being prepared to give the technical details of the Needles experiment and and an analysis of its effects. It will indicate what top astronomers such as Leo Goldberg think about the radioastronomical effects of the Needles experiment. It appers that Needles is under the supervision of Lincoln Laboratory for the Defense Department at the present time. Two men primarily responsibile for the technical analysis of the effects are Mike Villard of Stanford and Walt Morrow ? of Cambridge.

Relationship of NASA to Scientific Community

Although the discussion was supposed to be concerned with the space science program in general, it seemed to revolve primarily upon the problems that different members of the Panel had encountered in their relationships with NASA. A letter had been received by Dr. Rossi from Jim Van Allen which supported the general feeling of poor scientific-NASA relations.

Dr. Kistiakowsky attended portions of the meeting and he outlined the specific problems on which he asked for a decision.

1. A letter from the President to Glennan told him to improve the astronomy program.
2. A letter from Glennan to the President said everything was o.k.
3. Conversations between Glennan and Kisty concerning the Space Science Board relationship to NASA is that outside scientists are to suggest broad programs. The Space Science Panel relationship is quite different, because the Panel is an actual Government organization and although it must realize certain limitations, it can criticize procedures programs, activities, etc. because it is an arm of the President. He wants from us concrete recommendations for NASA improved procedures.
4. Kisty also desires a half page memorandum for the President concerning the improvement of the program in astronomy. He feels that both the recommendations for NASA and the memorandum concerning the astronomy program should be drafted after a conference with Dryden.

Dr. Berkner made a few comments which may be summarized as follows: (1) We did have a shortage of vehicles, (2) By 1963-65 we will need science to fill the available payloads, (3) fundamental science needs to be greatly increased and supported by NASA.

Dr. Rossi made several suggestions. First, the problem of plasma measurements of planetary probes indicates that the JPL-NASA relationship is very poor. JPL wants out-house research but it must be set up by NASA headquarters.

Comments from Schwartzschild - The astronomy program has definitely improved due to the high-level work of Kisty, the President and Glennan. For example, there seems to be a greater number of vehicles authorized. On the working level, however, the situation is terrible. He recommends an working group on a project consisting of no more than 3 men: project engineer, payload engineer and a scientist.

Dr. Rossi added that early participation of the scientists in the project is desirable.

Comments from Hebb - He feels the Panel should stay away from detailed setup before general recommendations are made. He suggests the formation of an advisory committee of outside scientists to advise Glennan directly.

Dr. Kisty recommended that an eyes only memorandum for Glennan, Dryden and possibly Horner be prepared outlining the Panel's recommendations. This memorandum to be followed by a meeting with Dryden to discuss the details of the recommendations. The Panel outlined the points to be covered in this memorandum and Purcell allocated each of the specific points to certain members of the Panel to be written. Arrangements were made for a meeting with Dr. Dryden on May 5th, and Purcell and Lord are to compose the letter from the wirtten suggestions of the Panel members.

D. R. Lord