The U.S. Space Programme

One of the most comprehensive, and yet concise, surveys of the scope and intentions of the American space exploration programme was recently given by Major General Don. R. Ostrander in an address at Western Michigan University. We are pleased to reproduce the major portion of his speech in this issue.*

The National Aeronautics and Space Administration, which governs the civilian development of astronautics in the United States, has its headquarters in Washington, D.C. It is headed by Dr. T. Keith Glennan and his deputy is Dr. Hugh L. Dryden.

Before coming to N.A.S.A., Dr. Glennan was President of the Case Institute of Technology in Cleveland, Ohio, and is currently on leave from that institution. During the War he was Director of the Navy's Underwater Sound Laboratories at New London, Connecticut, and he has also served since the War as a member of the Atomic Energy Commission. Dr. Dryden, prior to his appointment as Deputy Administrator, was Director of the National Advisory Committee for Aeronautics, our predecessor organization. Both Dr. Glennan and Dr. Dryden have been with N.A.S.A. since its formation in October, 1958.

Under the Administrator are five major staff offices, or Directorates, that plan, integrate and manage our total research and development programme. Taking these five Headquarters activities in turn, we have first of all an Office of Business Administration which supervises the normal function of personnel, procurement, supply, transportation, etc., in support of our technical activities.

Next, in the area of basic research, we have the Office of Advanced Research Programmes, where emphasis is placed on the application of basic sciences to aeronautical and astronautical problems, in order to insure our continuing advancement in the state-of-the-art in these areas, and to provide a sound scientific background and basis for our development programmes.

Closely allied to the Office of Advanced Research Programmes, but somewhat more specialized in its purpose, is the Office of Life Science Programmes. It is in this area that we relate our research findings to what, certainly, is one of the most exciting facets of space exploration and, at the same time, the one that presents some of the greatest problem areas. I refer. of course, to our programme to send man into space. The effects of acceleration, deceleration, weightlessness, and cosmic radiation on the human body are just a few of the problems that must be solved. This Office is also organizing our investigations as to the possibility of life-forms on other planets.

The translation of this research work into more specific and material things is divided into two organizational departments. One is my own organization, the Office of Launch Vehicle Programmes, which is responsible for developing the rocket boosters and supervising their launch operations, in order to place a payload into orbit or to probe outer space. The other is the Office of Space Flight Programme which provides the spacecraft or payload required to obtain the information or to perform the function that we desire on a specific space-flight mission.

Relatively speaking, the N.A.S.A. Headquarters is a fairly small organization, with about 600 people, and is staffed primarily to plan and supervise an integrated space programme. The bulk of our actual day-to-day scientific and development activity, however, is conducted by our field establishments, consisting of four research centres, three space flight development centres, and three rocket launching facilities—one at Cape Canaveral in Florida, one at the Pacific Missile Range on the west coast, and the third at Wallops Island, Virginia.

A field establishment of this size and diversity did not, of course, materialize overnight nor during the short time that N.A.S.A. has been in existence. The four research centres were absorbed with other sections of the National Advisory Committee for Aeronautics when N.A.S.A. was created in 1958. (Incidentally, in this area we are still responsible for the aeronautical research activities formerly conducted by the N.A.C.A., and are active in matters dealing with aviation, but there has of course been an inevitable shift of emphasis from the problems of conventional aircraft to the more demanding problems of space exploration.)

In addition to the nucleus of the N.A.C.A. staff and facilities, the N.A.S.A. absorbed from the Naval Research Laboratory the group which conducted the Vanguard satellite programme in connection with the International Geophysical Year, and from the Army the Jet Propulsion Laboratory of the California Institute of Technology and Dr. Wernher von Braun's group at Redstone Arsenal. Of our total staff of around 16,000 people, therefore, only a relatively small number represent new Government employees.

Research Centres

Taking first the area of basic research, I would like now to describe for you the scope and responsibilities of these field activities. The Langley Research Centre,

* *Director, Launch Vehicle Programmes, National Aeronautics and Space Administration.*

located at Hampton, Virginia, is the oldest of the former N.A.C.A. laboratories and the largest of our research activities. Here a staff of some 3200 people is occupied with such basic problems as the physical limitations of materials and structures, the physics and aerodynamics of re-entry vehicles, continuing work in aircraft aerodynamics, and fundamental research in stability and control.

At Cleveland, Ohio, we have the Lewis Research Centre, where a staff of 2700 is concerned with investigations relating to all aspects of aircraft and rocket propulsion. Research programmes are now active on chemical rockets, with emphasis largely on new and advanced high energy propellents, on nuclear rockets, and on electrical propulsion devices.

Much smaller in size than the other activities, but unique and specialized in its own right, is the Flight Research Centre at Edwards Air Force Base, California. It is located on the edge of Rogers Dry Lake, along with the Air Force Flight Test Centre, and it takes advantage of the 75 square mile flat surface of the lake as an ideal testing ground for research aircraft. A current staff of 416 people is engaged almost full-time on flight testing the X-15 research aircraft. Although this project comes under the general heading of aviation, it actually represents a first, but very significant, step toward ultimately placing a man into outer space, since this aircraft is designed for a maximum speed of over six times the speed of sound, and a maximum altitude of 250,000 ft.

Also located in California is the Ames Research Centre at the Moffett Naval Air Station in the Santa Clara Valley. This group of about 1400 people conducts research in the environmental physics of space operations, including simulation techniques, gas dynamic research at extreme speeds, and automatic stabilization and guidance and control of space vehicles. In the field of aviation they are also engaged in an active programme in connection with V.T.O.L. aircraft.

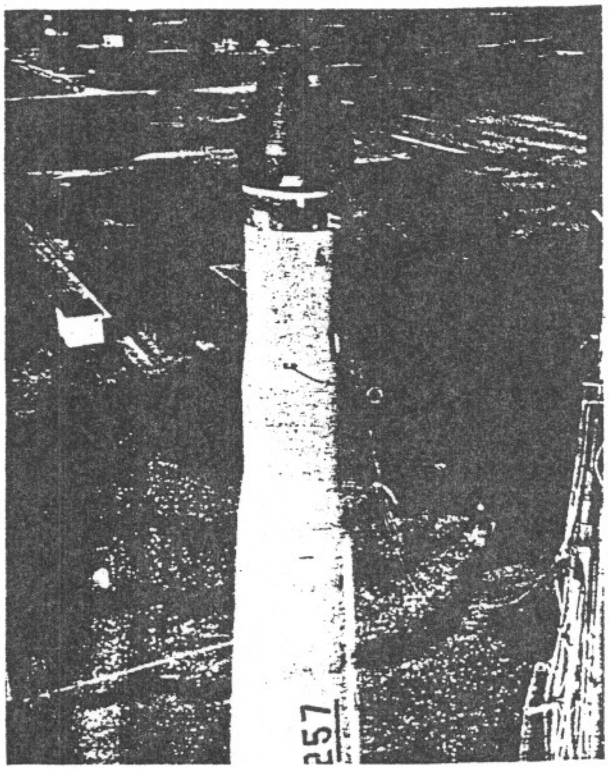
Whereas these research centres generally do their work in their own laboratories, and are staffed with relatively small groups of highly trained scientists representing a great diversity of skills and applications, on the development side we conduct a much greater proportion of our work by contract, both with industry and with universities and other non-profit research organizations. Here we require in general larger numbers of people and a greater investment in facilities and equipment because of the sheer size of the programme.

Development activity with N.A.S.A. is divided into two major material areas: Launch Vehicles and Spacecraft. Supporting the Spacecraft development programme are two centres, each concerned with a specific area of space operations. Responsibility for development of Earth-orbiting craft or satellites is vested in the Goddard Space Flight Centre, which is the only new organization we have formed. It is located at Beltsville, Maryland, just north of Washington. The staff consists of 2000 people, with the original Vanguard satellite team as a nucleus. The major programme elements of this Centre are scientific satellites, sounding rockets, the manned space programme, and the application of space vehicles to useful purposes, including communications and meteorology.

The other major field of spacecraft development is assigned to the Jet Propulsion Laboratory at Pasadena, California. This laboratory is operated for N.A.S.A. by the California Institute of Technology, and is concerned with the exploration of deep space, including unmanned lunar and interplanetary flights.

Development of our launch vehicles is concentrated at the George C. Marshall Space Flight Centre at Huntsville, Alabama, under the leadership of Dr. von Braun. As I mentioned, this operation is being transferred to us from the Army Ballistic Missile Agency and will be officially established under N.A.S.A. on 1 July. A total staff of 5500 people is now planned for this Centre.

In addition to the development of vehicles, the group under Dr. von Braun will also be responsible for the associated vehicle launch operations. For this function, missle-firing operations have been established at Cape Canaveral, Florida, under Dr. Kurt Debus, who has launched all of Dr. von Braun's missiles for him since the early days at Peenemunde in Germany. We will also establish a group under Dr. Debus at the Pacific Missile



AbleStar mated to the Thor first-stage on the launching pad at Cape Canaveral.

Aerojet-General Corporation

Range on the west coast. The operation on the west coast will be smaller in size and will be used principally for spacecraft requiring a polar orbit. At Wallops Island, off the Virginia coast, we have another small launching organization which conducts numerous launchings of smaller sounding rockets.

Space Research

An organization such as I have just described is, in essence, a collection of skills; but these skills have little meaning, of course, unless they are properly organized and directed to meet specific missions and objectives. In general, the objectives for our civilian space exploration programme can be grouped into three major categories.

The first category is our Space Sciences Programme, which is fundamental to all of our effort in that it provides the basic scientific knowledge that is essential to the development of specific uses of the space environment. In this area, instrumented stellites and space probes measure and record the scientific properties of the atmosphere, ionosphere, and both nearby and outer space, and as time goes on will provide us with basic information on the origin, composition, and environment of the Moon and the planets. In an overall sense, we have to expand our fundamental knowledge of space and its characteristics and concurrently develop the material and techniques that will allow us to probe even further into space. You might well ask whether this is not just a vicious cycle, wherein each new bit of knowledge we gain simple creates an insatiable desire for more knowledge and with it an even greater demand for new developments. The answer, quite obviously, is yes. However, I think the important point is that this process is not performed in a pure vacuum of intellectual curiosity. Both the elements of scientific exploration and the development of practical applications have to be integrated and balanced in relation to our long-range objectives, and no one are can be carried on without the support of the other.

The second category in our programme is this practical application of satellites to useful ends to benefit our day-to-day pattern of living. In this area we can already foresee tangible and very significant advances in the fields of communications, meteorology and navigation through the use of satellites. Our first meteorological satellite, Tiros I, launched in 1960, will be followed by its successors, Tiros II and Nimbus, each a little more complex and sophisticated, and contributing, we hope, to major advancements in weather forecasting. No less significant is our Project Echo, which will place metallic-coated, plastic balloons into orbit to be used as passive reflectors off of which we can bounce radio signals to improve our long range communications. Our first launch in this series, in May, was unsuccessful, but we have another scheduled later in the summer.

Man in Space

The third category is concerned with travel of man into space with anticipated trips to the Moon and, ultimately, travel to the other planets. As you know, we are already deeply engaged in Project Mercury, as this programme is called, and in other scientific investigations that we hope ultimately will lead to space travel. As to the immediate benefits, there is little question that a successful launching of man into space would do a great deal to enhance our national prestige. However, this is not the object of Project Mercury. The goal is to determine the degree to which man can tolerate the environmental conditions of spaceflight and still perform operations sufficiently important to warrant his participation in future space explorations, with all the additional complexity his presence imposes.

During 1960 our efforts were directed primarily toward major tests of new vehicles, oribital experiments in meteorology and communications, and, on the more dramatic side, the first sub-orbital flight of a manned space vehicle under Project Mercury.

Assuming continued success in the schedule of tests for Mercury, the first orbital flight will occur in 1961. We also plan the launching of an advanced lunar impact vehicle during the latter part of 1961 or the early part of 1962.

From this point on, our major milestones include a comprehensive programme of unmanned exploration of the Moon and nearby planets leading toward manned circumlunar flights—flights around the Moon and return—and ultimately a landing of man on the Moon during the early 1970's.

This undertaking is ambitious by nearly any standard, but what I think is perhaps even more significant is the unique character of the basic mission and responsibilities of our organization. Under N.A.S.A. we have for the first time, I believe, a Government agency that is devoted solely to research and development. Although both military and other civilian agencies are engaged in research, their efforts are undertaken only to the extent they support the agency's principal mission. In the case of N.A.S.A., our sole and only mission is the research and development itself, with the end product being turned over to others for specific application.

This gives us some unique advantages, in that we are not tied to immediate objectives or specific end products—we can project our programme beyond immediate and practical considerations and seek out and create opportunities rather than wait and let them evolve through normal processes. On the other hand, it presents us with some very real problems and difficult decisions in that we have to exercise extremely selective judgment in choosing from a virtually nlimited field of potential scientific experiments, each with its very sincere and enthusiastic proponents among the scientific community.

Booster Programmes

The underlying philosophy in our vehicle development programme rests upon three fundamental principles.

First, we must create a fleet of standard vehicles with a minimum number of different designs and configurations. The inevitable limitation of dollars alone dictates that we must take this approach.

Second, and closely allied to the first, we must attain a high degree of reliability through repetitive use of these basic vehicles, much as the automotive industry has achieved reliable cars through the millions of miles of driving on each of their standardized series.

And third, to avoid early obsolescence, we must insure that each new vehicle we develop incorporates the most advanced technical approaches and growth potential consistent with the reliability we require.

As I have indicated, the first two of these principles—minimum variety and repetitive use of standardized vehicles—are dictated largely by economy. The costs of developing launch vehicles are already high and they are going up in a geometrical progression with every new, larger, and more advanced vehicle that we develop.

The need for reliability through repetitive use of the same vehicle is, I think, obvious. These devices, being essentially expendable, must function properly the first time or the entire cost of the operation is wasted. By using the same type of rocket vehicle over and over, rather than trying to use a variety of vehicles, each designed for a specific purpose, we build up our experience level on the vehicle, are able to detect and eliminate the "bugs" and the defects sooner, and consequently arrive at a high level of reliability earlier in our programme.

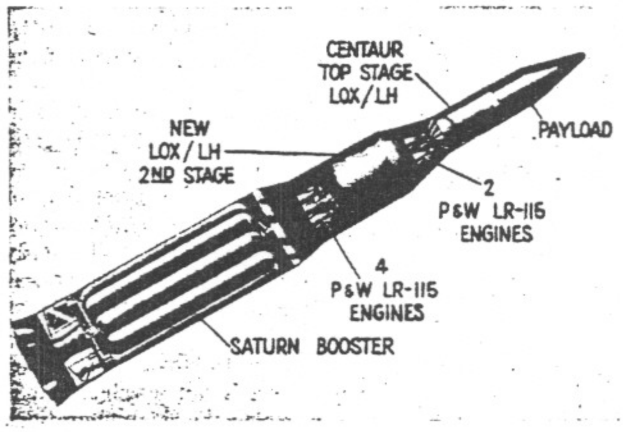
Now let us look at our past, our present, and our planned fleet of vehicles to see how we are applying these operating principles.

Two early vehicles, which have already been retired, were the Jupiter C, which served us so well back in 1958 when we so greatly needed a U.S. satellite in orbit to repair, in some measure, our badly mauled prestige; and the Vanguard I.G.Y. satellite vehicle which, in spite of its troubles, more than earned its development cost in the information provided by the three scientific payloads it orbited.

Also retired last year was the Juno II, based on the Jupiter I.R.B.M., and the Thor-Able, based, of course, upon the Air Force Thor I.R.B.M. Thor-Delta, which is this same Thor-Able improved through various modifications including an accurate and flexible radio guidance system, will be used throughout 1961 in a twelve-vehicle programme but we plan no follow-on procurement beyond that.

All of the vehicles mentioned are bing replaced by two new vehicles. The first is the Scout, which is a small four-stage solid propellent rocket. The other is the Thor-Agena B, which is basically the same vehicle as is being used very successfully in the Air Force Discoverer programme. The Scout was selected because of its relatively low cost, about $750,000 per vehicle, and the Thor-Agena B was chosen because of its combination of greater payload, flexibility of operation, and potentially high reliability.

As far as payload capability is concerned, Vanguard and Jupiter C could place in a 300-mile orbit about a



Cutaway diagram of the Saturn C-1. First launching of the 1·5 million lb. s.t. booster with dummy upper stages is scheduled from Cape Canaveral next summer.

National Aeronautics and Space Administration

25-lb. payload. Juno II could perform the same mission with a 100-lb. payload, and Thor-Able with about 200 lb. Thor-Delta will more than double this performance with about a 480-lb. capability for this particular mission. Of their successors, Scout can handle a 150-lb. payload for a fraction of the cost of its predecessors, and Thor-Agena B will be able to put 1250 lb. in a 300-mile orbit.

This same Agena B second stage used on top of the Thor will also be used by N.A.S.A., as well as the Air Force, as a second stage of the Atlas I.C.B.M. This will increase our payload capability in a 300-mile orbit to about 5300 lb.

Later in 1961 we are scheduled to launch our first Centaur. The Centaur will be the first rocket vehicle to employ a high energy upper stage, using liquid H_2 and liquid O_2 instead of the kerosene and liquid O_2 we have used so far. The added thrust that we gain by using hydrogen as a fuel gives the Centaur half again the payload when used on a trip to the Moon, which is one of its principal missions in the N.A.S.A. programme. For the first time, in Centaur, the U.S. will have a launch vehicle able to duplicate the payload capability of the Russian Sputnik vehicle.

In addition to the Scout, the Thor-Agena, the Atlas-Agena, and the Centaur, which will be used as standardized vehicles in our continuing programme, the Saturn vehicle is being developed under the management of Dr. Wernher von Braun's group at the Marshall Space Flight Centre. Saturn's first stage consists of a cluster of eight ballistic missile-type engines, with a total thrust of 1,500,000 lb. On top of it we will have two upper stages using the same hydrogen-oxygen engine being developed for the Centaur. When we get this Saturn C-1 vehicle, which is the initial version of Saturn, our payload capability will be over 25,000 lb. in a 300-mile orbit.

In the second model of Saturn, called C-2, we will insert another stage using four 200,000-lb. thrust LO_2-LH_2 engines between the first and second stages of the C-1 version.

We have had a great deal of study and analysis in progress for the past year to try to define the vehicle which will follow Saturn. The principal mission we have used in these planning studies has been that of landing a manned spacecraft on the Moon, then returning a 15,000 lb. re-entry package to the Earth. The study has followed two principal approached. The first was what you might call the brute force attack, known as Nova.

There have been many references to Nova, as a vehicle, in the press and elsewhere, Nova is not a vehicle—it is simply one of a number of possible vehicle configurations which we have considered for the use of the single 1,500,000-lb. thrust engine now under development. Under this brute force approach, six of these large 1½ million lb. thrust engines would be used in the first stage. Four hydrogen-oxygen stages could be piled on top of this big booster to give us the 15,000 lb. payload that we need to return a man to the Earth after landing on the Moon.

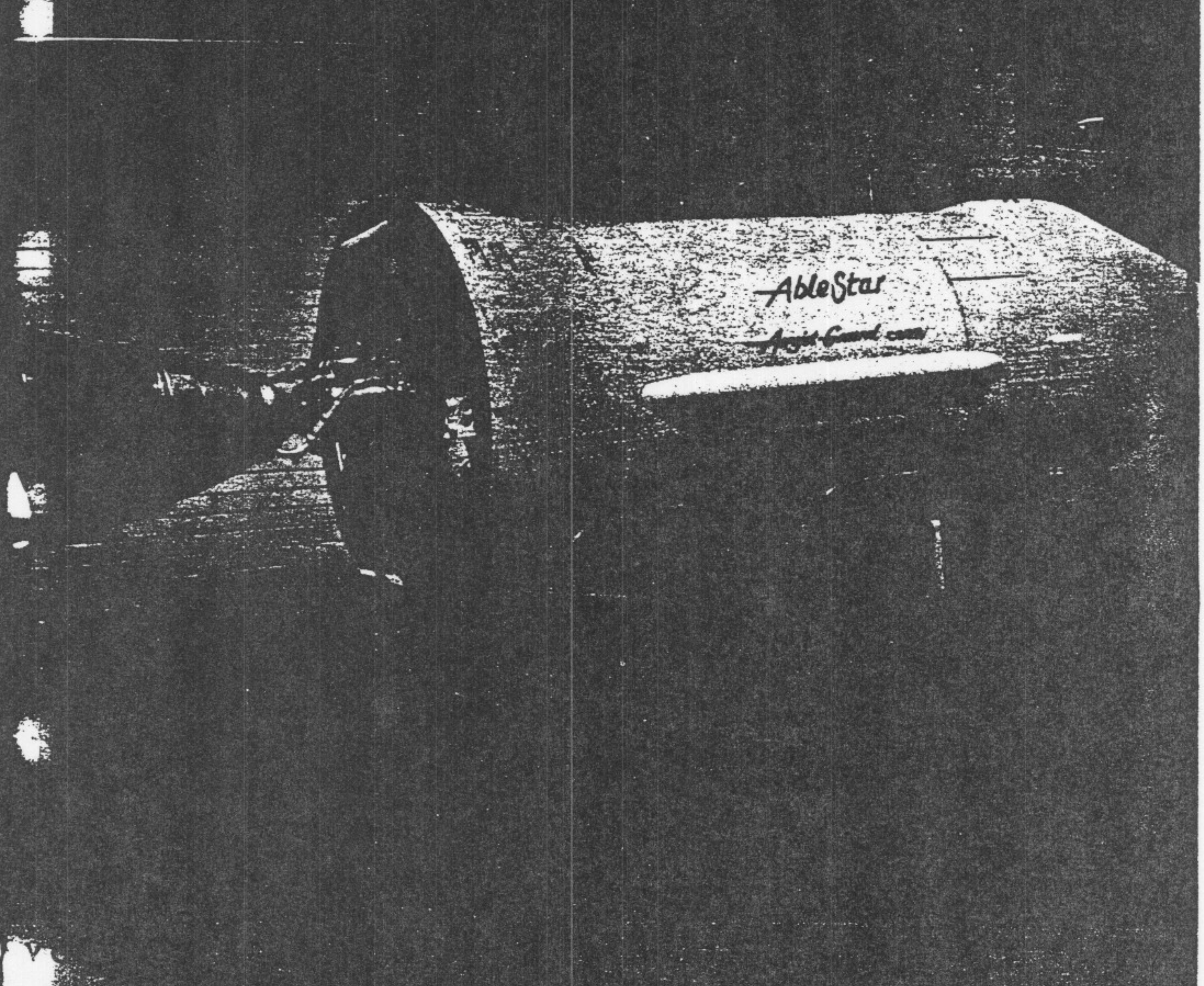
In all of the vehicles I have mentioned, the propulsion system is based on existing engine concepts wherein highly concentrated fuels are mixed with an oxidizer and burned in a combustion chamber. The resulting high temperature gas is accelerated through a jet nozzle, thus producing the thrust required to propel the rocket. For the initial boost to break away from the Earth's gravitational pull, we need this kind of extremely high thrust of relatively short duration. Once the vehicle is in space, however, the requirement reverses from high thrust of short duration to relatively low thrust for much longer periods of time. To meet this second requirement, we have initiated two advanced programmes in propulsion. One is a nuclear rocket, in which a nuclear reactor, instead of chemical combustion, is used to heat the propellent and expand it through the nozzle. The other is a system employing electrical propulsion.

The encouraging results which were obtained from the initial nuclear rocket reactor test conducted by the Atomic Energy Commission last summer have stimulated our hopes that the large increase in efficiency which we get from using nuclear upper stages, with weights less than one-third that of conventional rockets for the same mission capability, can be acquired by the time our programme has reached the point where we need something beyond Saturn. Toward that end, the N.A.S.A. and the A.E.C. are increasing the pace of the Rover programme, as the nuclear rocket programme, is known, and we are aiming for an orbital flight test of a prototype nuclear rocket in 1965, on top of the Saturn as a launch vehicle.

The use of electrical propulsion appears to be somewhat further in the future, but it has some attractive features which appear to be uniquely applicable to the space programme. In essence, an electric rocket consists of an electrical power generator and a device to convert this power into thrust. There are several methods of converting electrical energy to thrust, but all are based on a concept of accelerating electrically charged particles to produce the desired jet stream.

Both the electric and nuclear rockets show considerable promise for space application because of their relatively high specific impulses. This high specific impulse, or amount of thust per lb. of propellent, reduces the total amount of propellent required and thus provides more room for the engine structure and payload. It is in this area, particularly, that we hope to find a major breakthrough in our capabilities.

Spaceflight



SOLAR SUNFLOW...
CRATERS OF THE ...
CONGRESS ...
THE SATURN FAMIL...
BACK FROM ORBIT ...
DYNA-SOAR ...
ECHO I ENCOUNTERS DARKNESS ...
INJECTING ECHO INTO ORBIT ...
THE U.S. SPACE PROGRAMME ...

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