NASA - LEWIS RESEARCH CENTER

PLUM BROOK STATION

SENIOR SCIENCE STUDENT TOUR

OCTOBER 8-9, 1964

PARTICIPATING HIGH SCHOOLS

ATTICA
BELLEVUE
BERLIN HEIGHTS
HURON
MARGARETTA
MILAN
MONROEVILLE
NORWALK
NEW LONDON
PERKINS
ST. MARY
ST. PAUL'S
SANDUSKY
SOUTH CENTRAL
WESTERN RESERVE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LEWIS RESEARCH CENTER—PLUM BROOK STATION
TAYLOR ROAD AND COLUMBUS AVENUE
SANDUSKY, OHIO 44871
TELEPHONE: 625-1123 TWX: 419-626-6010

IN REPLY REFER TO:

October 8, 1964

TO: High School Senior Students

FROM: The Plum Brook Director

It is my pleasure to welcome you today to the Plum Brook Station of the Lewis Research Center, National Aeronautics and Space Administration. NASA represents one of the greatest scientific endeavors ever undertaken. The agency and it's installations encourage the study of science and seek to aid in that pursuit through many educational programs. It is my hope that you will find your tour of the Plum Brook Station both interesting and profitable.

Alan D. Johnson
Director, Plum Brook Station

TOUR SCHEDULE

AREA NUMBER	AREA	REMARKS
1	REACTOR FACILITY	TOUR FACILITY
2 thru 9	ROCKET SYSTEMS LABORATORIES	BUS TOUR
10	HIGH ENERGY ROCKET LABORATORY	TOUR FACILITY
11	INSTRUMENT AND CONTROL AREA	TOUR, *, MOVIE AND REFRESHMENTS

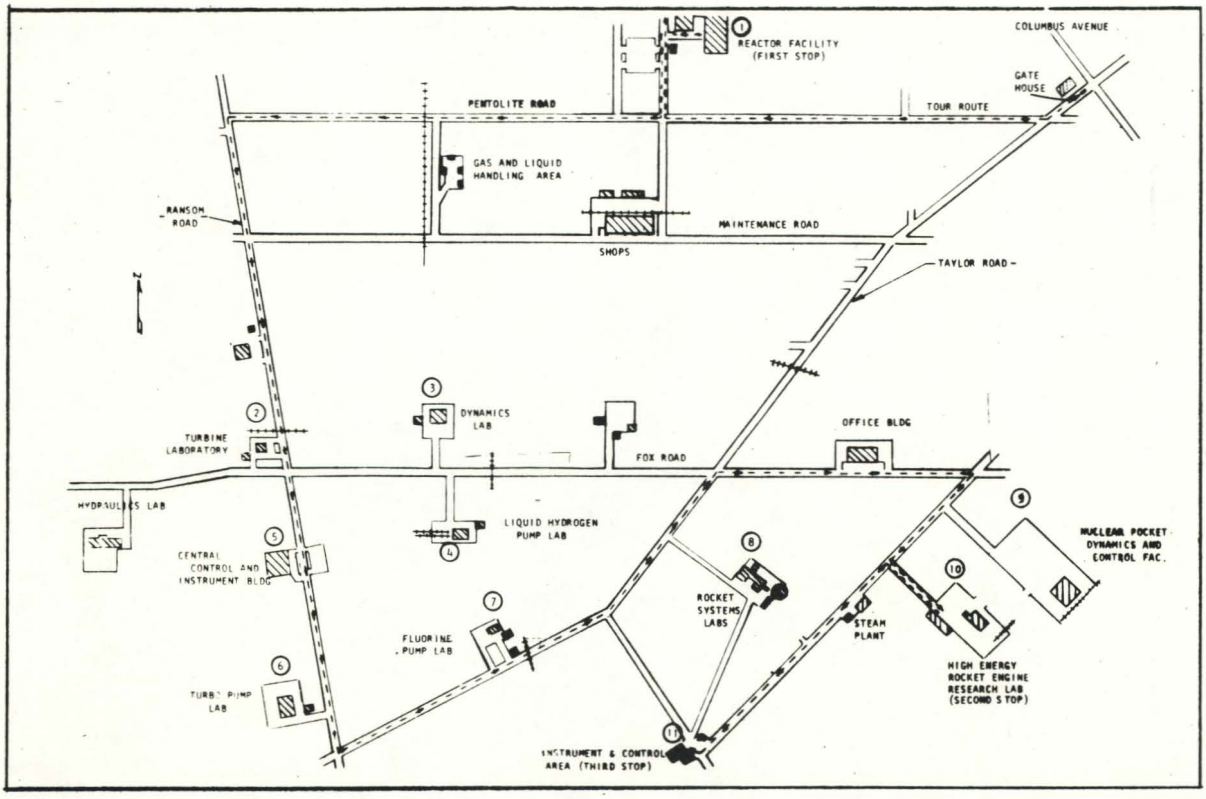
(* Engineers available to answer your questions, also Research Items on display)

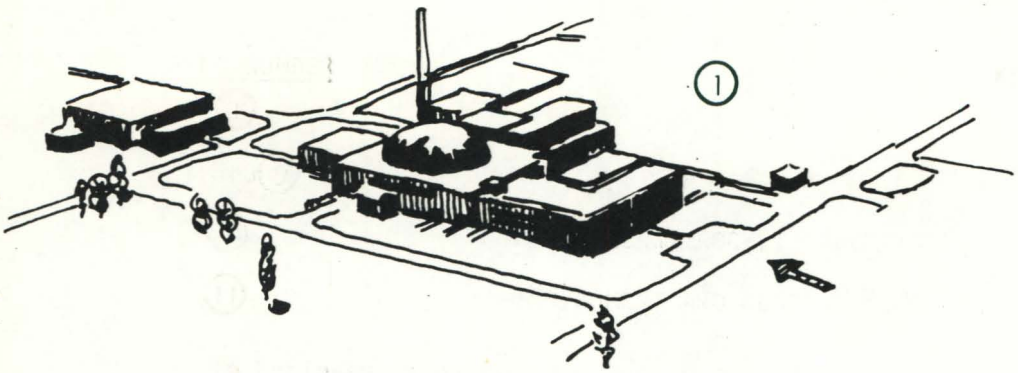
10 (To be viewed from 11 Instrument & Control Area)	HIGH ENERGY ROCKET LABORATORY	EJECTOR TEST RUNS Oct. 8 - 11:00 & 2:05 Oct. 9 - 11:10

NOTE: 1 through 11 - Descriptions on next 11 pages of Tour Book.

TOUR ROUTE

(Tour route may be altered as required by Research Operations)





REACTOR FACILITY

The $15,000,000 Reactor Facility is used to study materials and components under radiation conditions similar to those anticipated in full-scale Space Nuclear Rocket Systems and Space Power Systems.

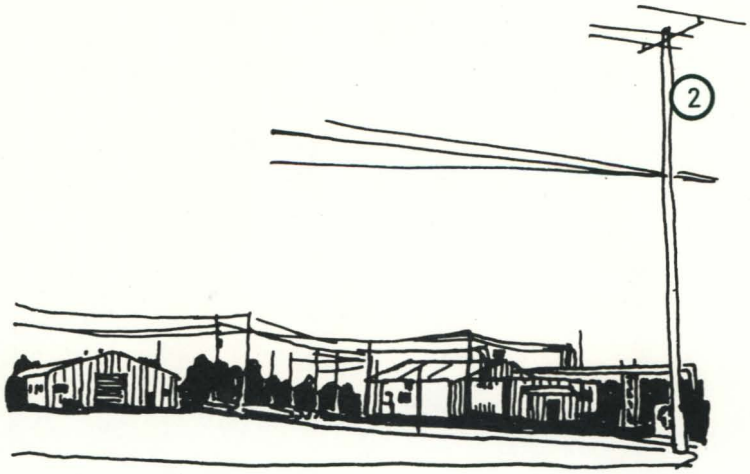
The Reactor can develop 60,000 kilowatts of thermal power. Its core is approximately a 30-inch cube and holds 27 fuel elements componsed of an enriched uranium-aluminum alloy.

At full power, 1,000,000 times 1,000,000 times 100 neutrons are passed through a square centimeter of a test sample's surface every second (or a thermal flux density of 4×10^{14} neutrons per square centimeter per second.)

During reactor operation three million gallons of highly purified cooling water are circulated per day through the core and the shielding quadrants around it.

A system of water canals 25 feet deep are used to move radioactive test materials from the reactor to storage areas and to hot laboratories for required testing.

At the present time, many tests are being performed, and resulting data will be used to build nuclear rockets and space power supplies for interplanetary exploration. Some of these tests are made at 400 degrees below zero to simulate space environment temperatures.

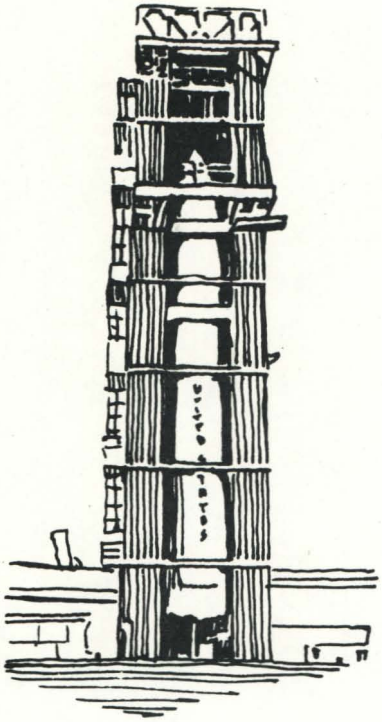


TURBINE LABORATORY

Turbines which are used to drive rocket propellant pumps for chemical and nuclear engines can be tested in this laboratory.

Power is provided by gas generators which operate on hydrogen gas and liquid oxygen.

Turbines developing up to 15,000 horsepower and speeds up to 60,000 R. P. M. can be tested in this lab.

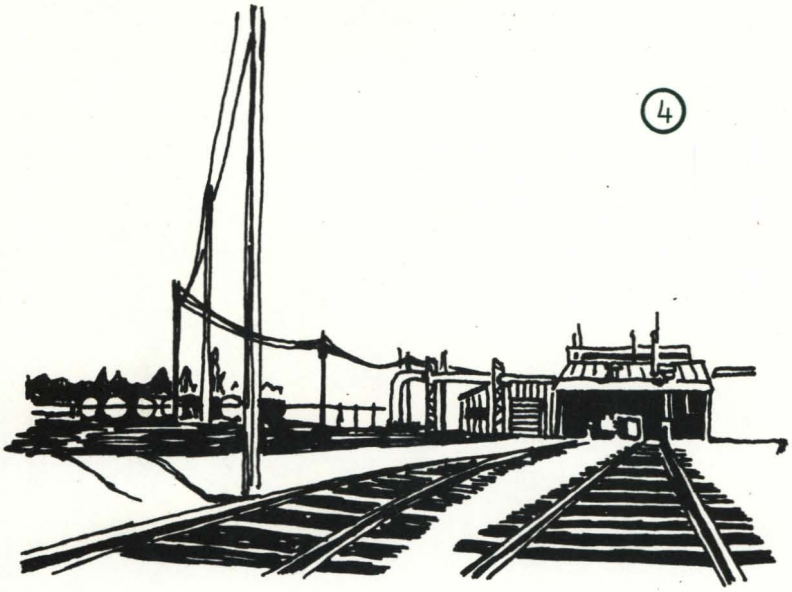


DYNAMICS LABORATORY

This 130-ft. stand is equipped with electromagnetic shake devices which can simulate forces encountered on lift-off and space missions.

At the present time, the Atlas-Centaur-Surveyor combination is being tested. Information from this test will help to insure the success of the Surveyor project, which is to soft-land an instrument package on the moon.

The Lewis managed Centaur vehicle is the nation's first high-energy fuel space vehicle (using liquid hydrogen (-423°) and liquid oxygen as propellants).



LIQUID HYDROGEN PUMP
LABORATORY

This laboratory is designed to test liquid hydrogen pumps of various designs at pump speeds up to 60,000 R. P. M. Data from these research programs will be used to design liquid hydrogen pumps for advanced chemical and nuclear rockets.

Liquid hydrogen is supplied to the pump via 6,000 gallon truck dewars and by 34,000 gallon railroad dewars.

CENTRAL CONTROL AND
INSTRUMENT BUILDING

This building contains remote control and recording instruments for most of the laboraties seen in this area. Since the laboratories are all remotely controlled with no personnel in the test area during a run,closed circuit television is used so that the test operator can visually observe the experiments which are taking place a quarter of a mile away.

Over 3,200 pairs of instrument lines and 1538 pairs of control cables connect this building to the test areas.

TURBO PUMP TEST LABORATORY

Rocket turbo pumps can be tested at this laboratory. The liquid hydrogen pumps are driven by hydrogen gas turbines. Also, experiments are being run at a second test area using boiling liquid hydrogen and testing pump inducers.

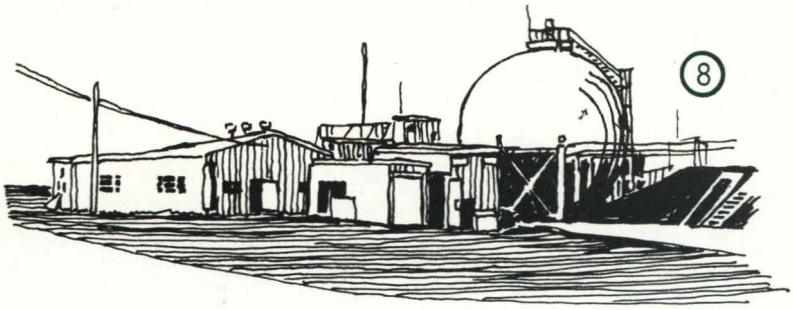
On a nuclear rocket engine, there will be a tremendous heat flow from the engine to the liquid hydrogen fuel tank. This causes the liquid hydrogen to boil and a pump must be designed to pump this boiling fluid. Various types of pump rotors are being tested.

The installation consists of a liquid hydrogen pump test rig submerged in the bottom of a 2,000 gallon vacuum-jacketed liquid hydrogen tank.

LIQUID FLUORINE PUMP
LABORATORY

Liquid fluorine pumps with speeds up to 20,000 R. P. M. and flow rates of 50 pounds per second can be tested at this laboratory.

Because fluorine is the most active oxidizer known, it has great potential in the chemical rocketry field.



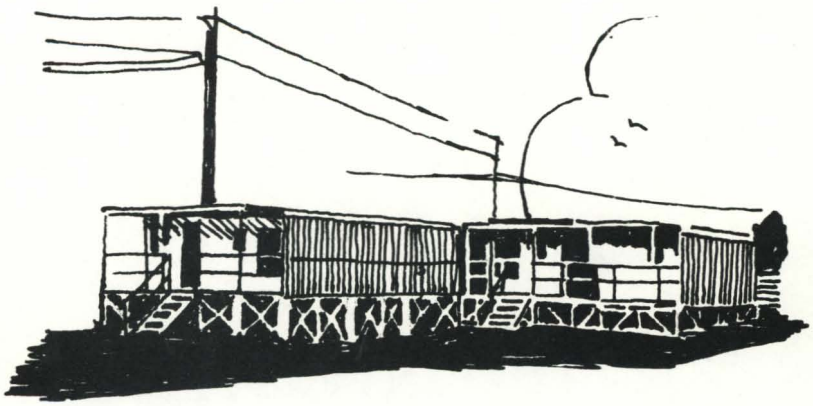
ROCKET SYSTEMS TEST LABORATORIES

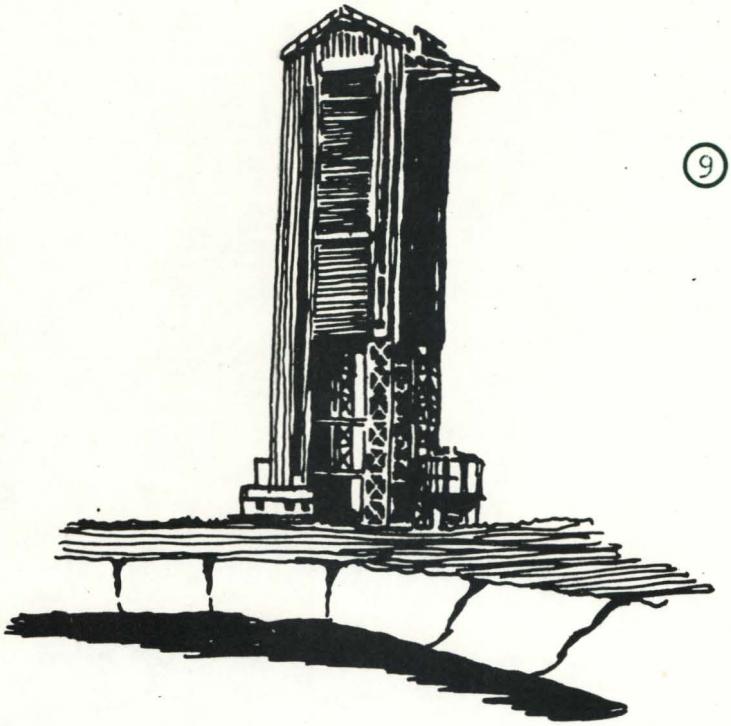
In this area, hydrogen-oxygen rocket engines are fired and data is obtained on heat transfer between the hot gases and the nozzle walls. Also, studies are made on heat transfer from the nozzle wall to the liquid hydrogen used to cool the nozzle. This heat transfer research is being done to support the development of a nozzle for nuclear rocket engines.

Also located in this area is a space environment tank, where various types of liquid hydrogen propellant tanks can be tested in space conditions. Also, various types of insulation can be studied.

The 38' diameter steel containment vessel is a hydraulics laboratory used to test liquid fluorine and liquid oxygen under pressures up to 400 PSI.

CONTROL AREA

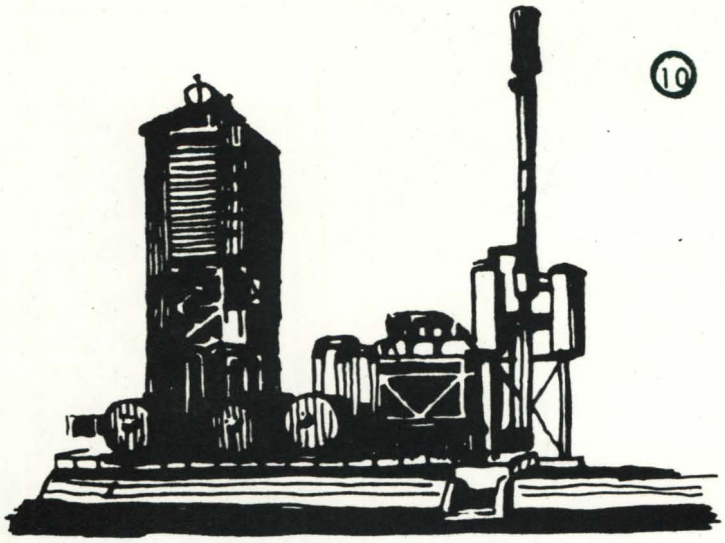




NUCLEAR ROCKET DYNAMICS AND CONTROL FACILITY

This 3.5 million dollar, 200 foot high facility is presently under construction and will be used for non-nuclear tests of various components for large nuclear rocket engines such as will be needed for interplanetary travel. A 200,000 gallon liquid hydrogen supply tank is presently being built in the front of the facility.

A 46,000 gallon liquid hydrogen run tank is installed in the tower and liquid and high-pressure gas will be supplied by rail car.



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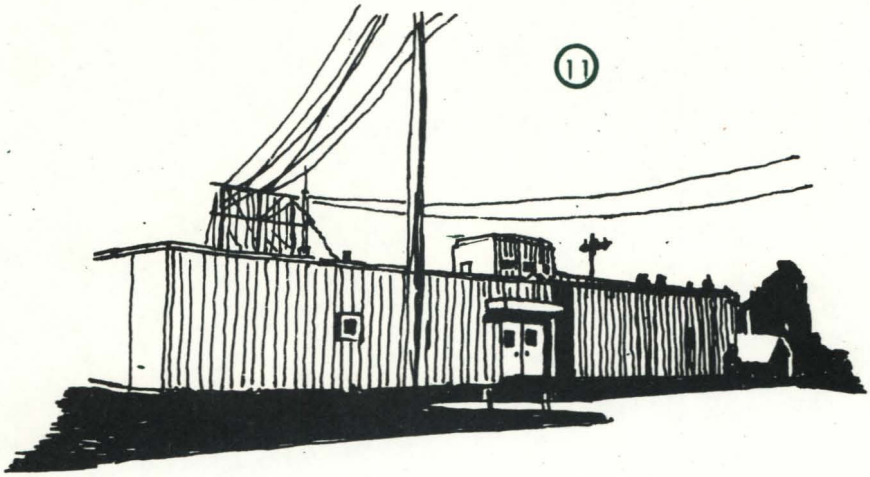
HIGH ENERGY ROCKET ENGINE
RESEARCH LAB

This laboratory is designed to test propellant systems and presently the NERVA (Nuclear Engine for Rocket Vehicle Application) is being tested. The investigations include turbopump tests, fluid instabilities in the engine flow passages, and equipment performance evaluations.

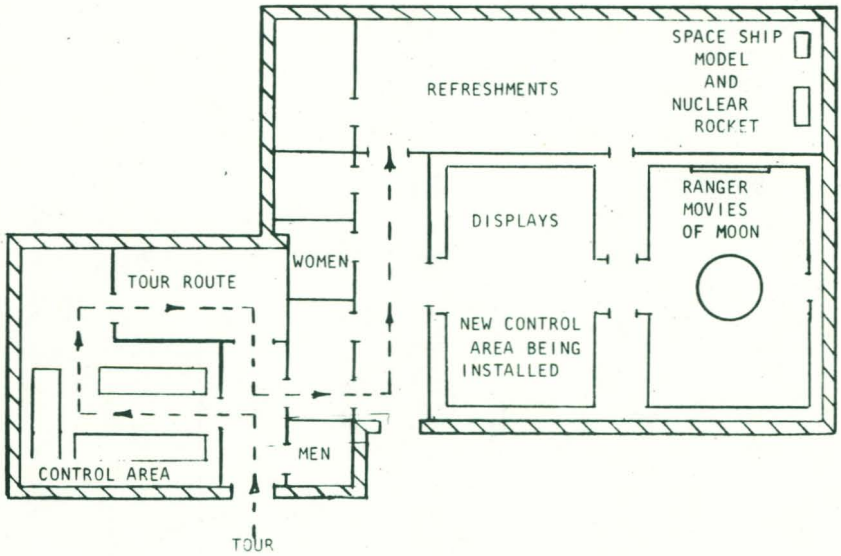


INSTRUMENT AND
CONTROL AREA

This building is the control area for four new facilities:

Hydrogen Heat Transfer Facility
Nuclear Rocket Engine Dynamics Facility
Spacecraft Propulsion Facility
High Energy Rocket Engine Research Facility

This area will be visited today and a building layout is shown below.

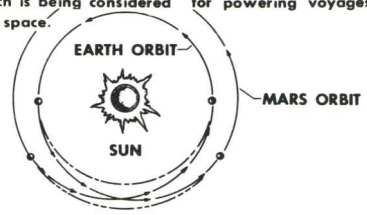


A THEORETICAL SPACE FLIGHT

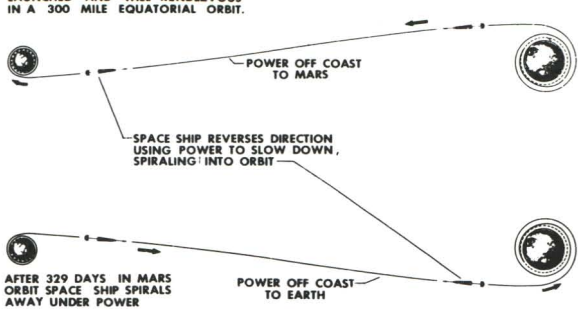
A MISSION TO MARS

Our frontiers of knowledge are being rapidly extended by satellites and probes into space. Much remains to be learned before manned flight between planets can become reality, yet such flight may come within the lifetime of many reading this.

The trip to Mars shown here is but one of many ways in which such a mission might be achieved. Although the space ship which will carry man on his first journey to Mars may not look like this model, it shows features of electric propulsion which is being considered for powering voyages into space.



SCHEMATIC OF FLIGHT PLAN



TRIP TIME BREAKDOWN

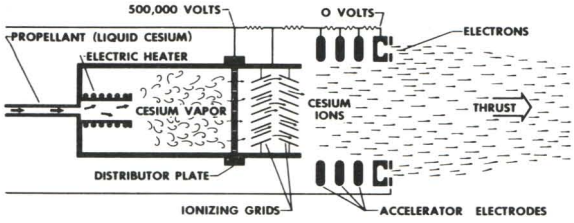
ESCAPE FROM EARTH ORBIT	140 DAYS	ESCAPE FROM MARS ORBIT	52
COAST TO MARS	268	COAST TO EARTH	268
DESCENT TO MARS ORBIT	74	DESCENT TO EARTH	70
WAIT FOR EARTH AND MARS TO BE IN PROPER POSITION TO START RETURN	329	TOTAL DAYS	1201

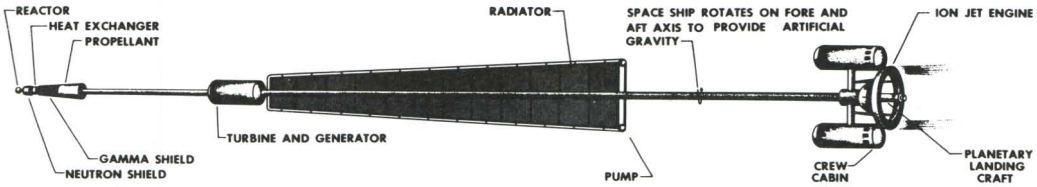
ELECTRICALLY PROPELLED SPACE SHIP

Electric propulsion systems accelerate a gaseous propellant by electro-static or electromagnetic forces to provide thrust to move the ship. Electric power generating equipment could be operated by a nuclear reactor.

This type of propulsion is attractive for interplanetary travel because of its ability to operate on much smaller propellant requirements than either chemical or nuclear rockets. Because of the heavy weight of the machinery required for this system, sections of the ship would have to be boosted into orbit around the Earth by chemical rockets. After assembly in orbit, the ship would proceed.

SCHEMATIC OF ELECTRIC PROPULSION UNIT (ION JET ENGINE)

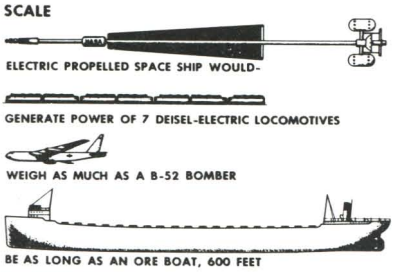




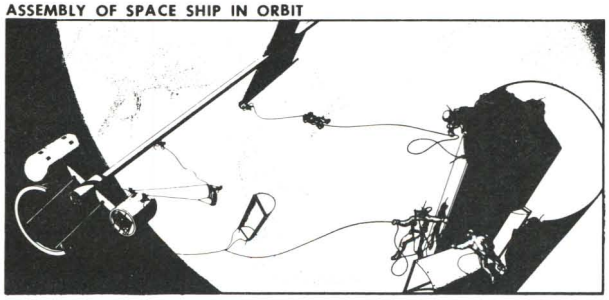
WEIGHTS (IN ORBIT AT START) TOTAL 322,000 LBS

CABIN	50,000	POWER PLANT	60,000
LANDING CRAFT	40,000	PROPELLANT	60,000
SUPPLIES (8 MAN)	96,000	STRUCTURE	16,000

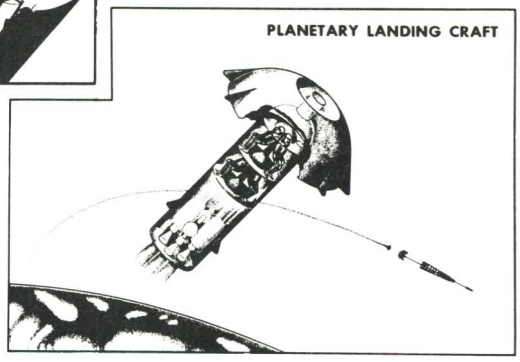
SCALE



ASSEMBLY OF SPACE SHIP IN ORBIT



PLANETARY LANDING CRAFT



ARRIVAL AT MARS AND RETURN TO EARTH

The space ship would orbit Mars during the wait period there. Landing on the planet would be achieved through use of the umbrella shaped, planetary landing craft at the rear of the ship. This craft, powered by chemical rockets, can detach and reattach itself while the ship orbits.

On return to Earth, the ship would again remain in orbit. Its crew would land by means of the planetary landing craft.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION