

SPACE JOURNAL

OF THE
ROCKET CITY
ASTRONOMICAL
ASSOCIATION

IN THIS ISSUE

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SPACE EXPERTS

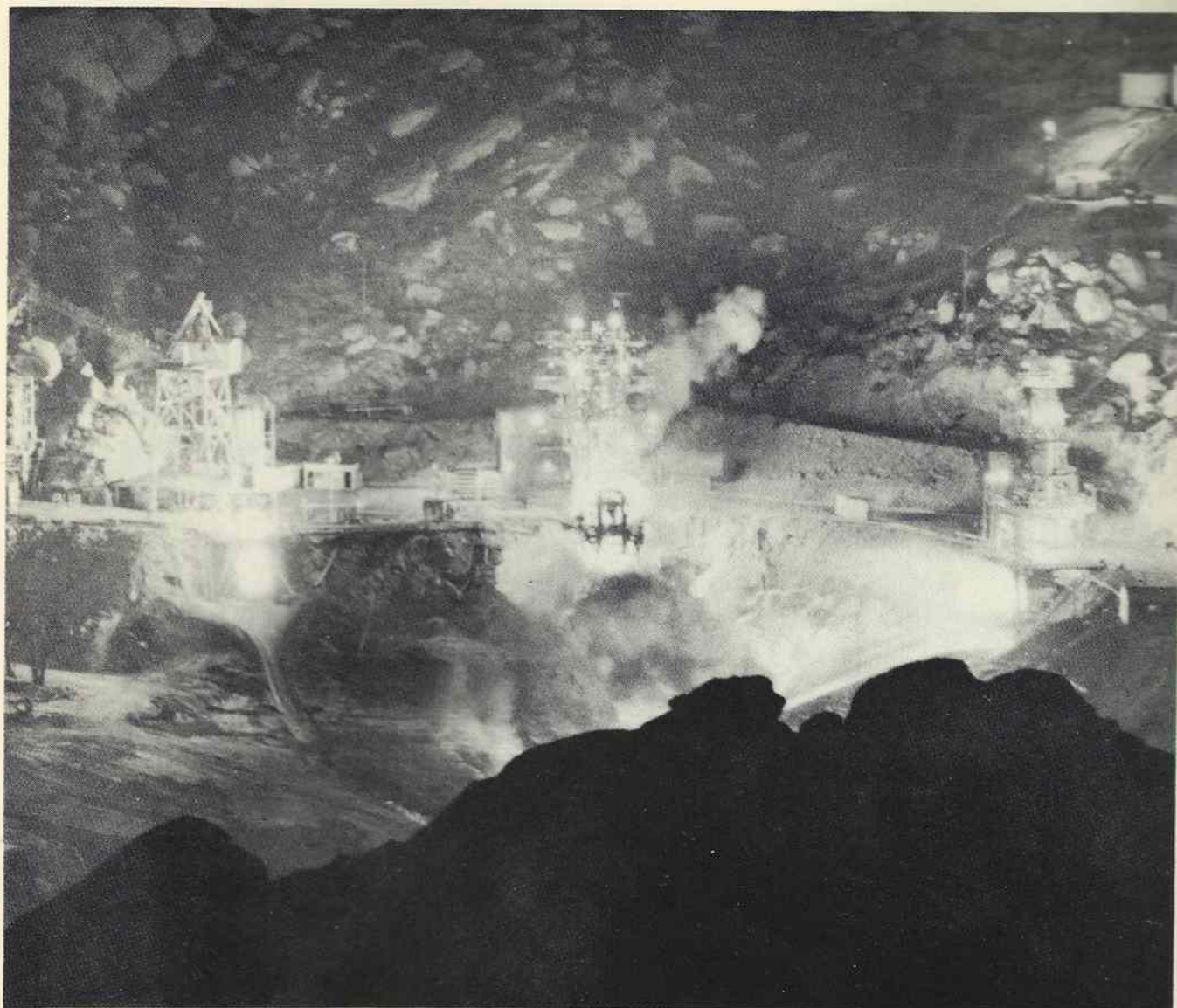


OBERTH: FATHER OF ASTRONAUTICS

SUMMER 1957

60c

FIRST EDITION



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BUILDERS OF POWER FOR OUTER SPACE

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RELATIVITY

There was a young lady named Bright,
Who travelled much faster than light,
She started one day,
In a relative way,
And returned on the previous night

—Anonymous

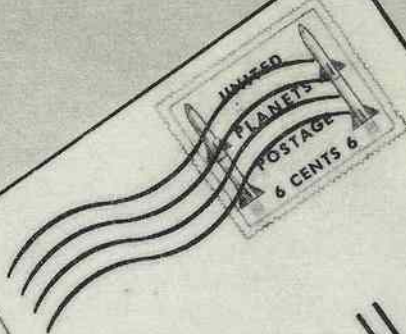
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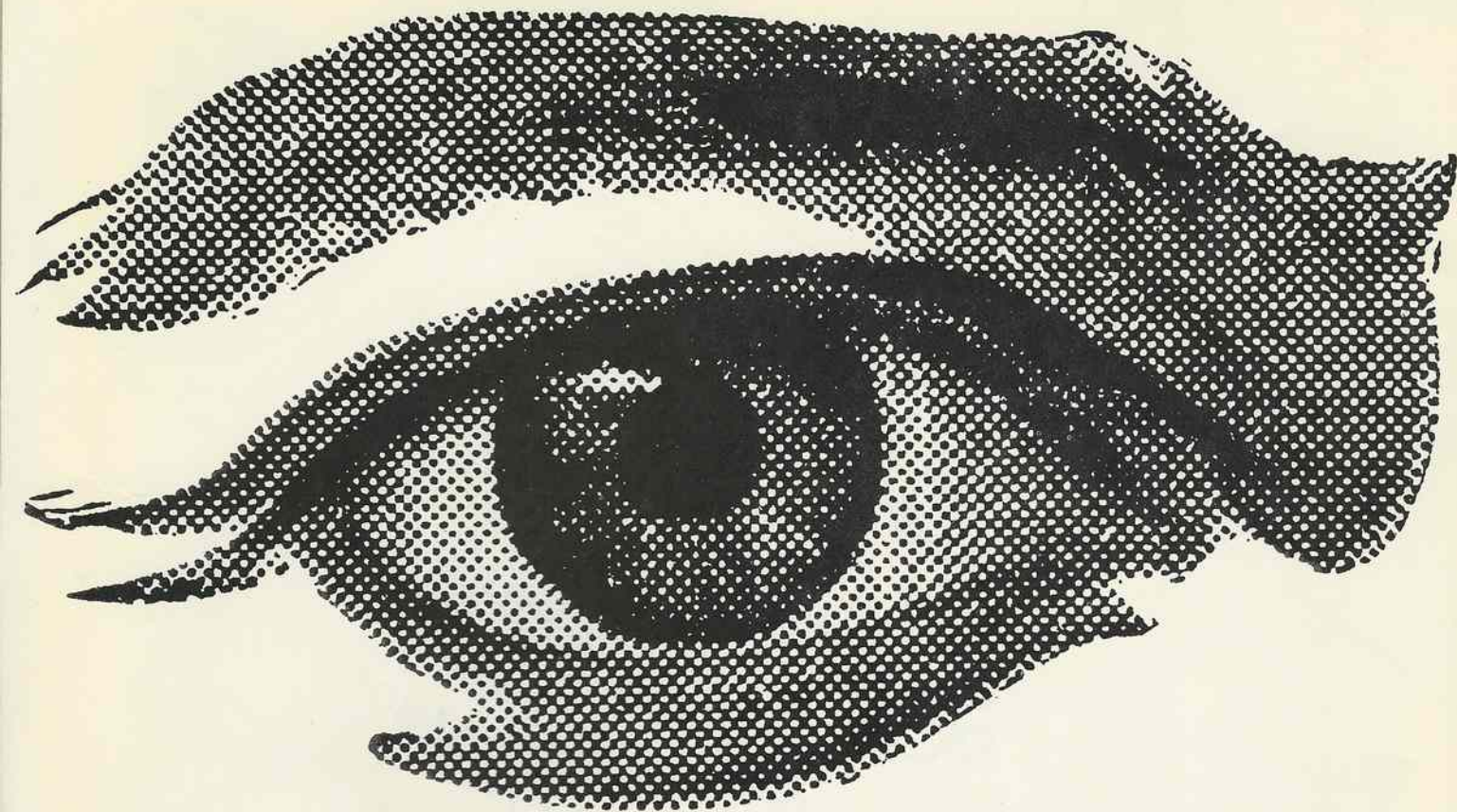
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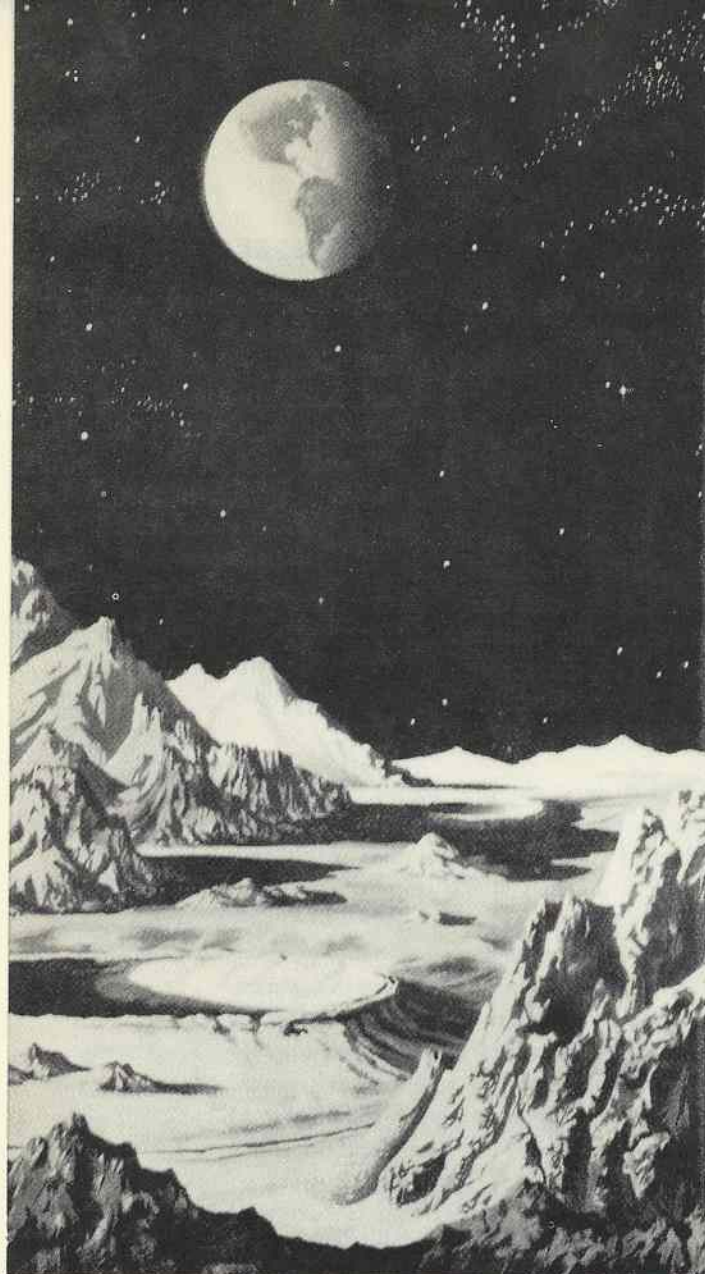
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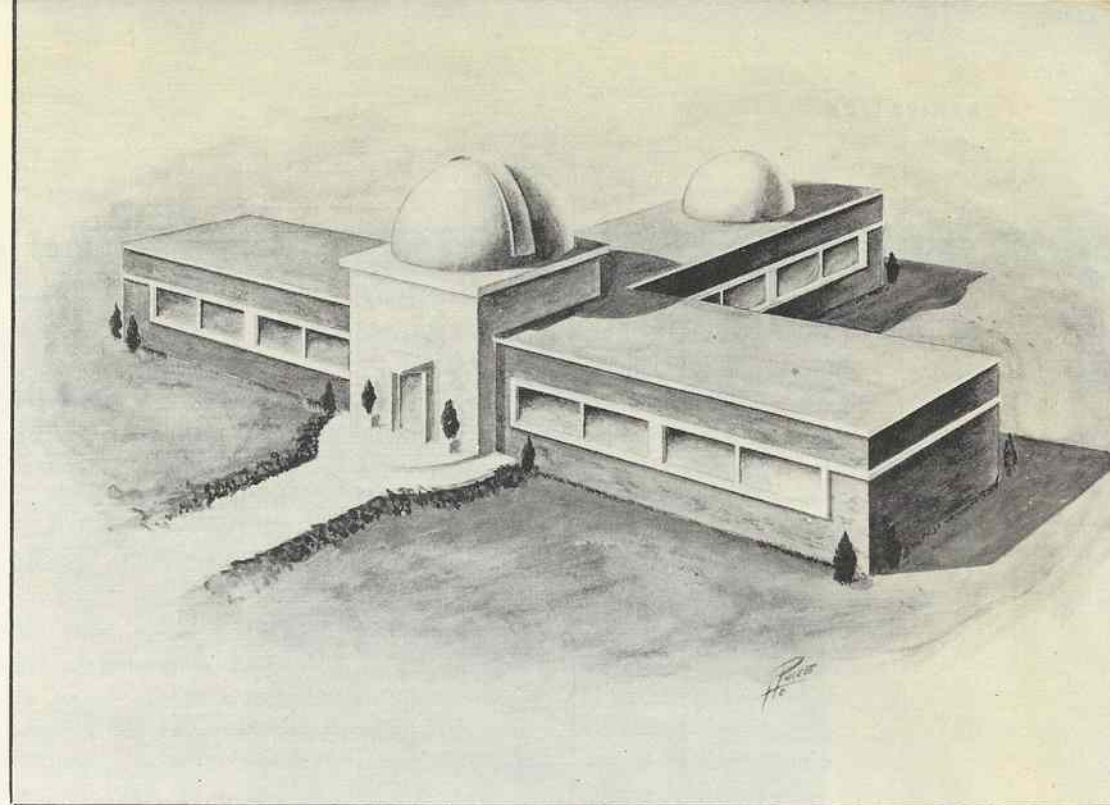
The space experts you will meet through the pages of SPACE JOURNAL agree that the first unmanned guided missile will strike the moon during the next ten years. Most of these men agree that within five years after that it will be possible for a manned space ship to circle the moon and return safely to earth.

The fact that man will travel beyond the limits of the earth's atmosphere and overcome its gravitational pull has been assured by scientific developments of the last few years. Nevertheless, there is still great argument about methods and about the unknowns of the strange environment enroute and at the destination. The first concentrated earthwide attempt of man to understand more about his environment on earth and in space commences with a cooperative effort by all nations (including Russia) on July 1, 1957. This dynamic program, labeled the International Geophysical Year (IGY), extends to December 31, 1958, and is designed to provide the answers to many perplexing questions which scientists are asking in preparation for man's conquest of space.

It seems appropriate, then, to launch the SPACE JOURNAL from the Rocket City, USA, at a time when men of all nations on earth are truly beginning to "look to the stars." The SPACE JOURNAL is unique among American scientific publications in that it recognizes from the outset the tremendous desire of the not-so-scientifically-minded man to understand more about science and its ever increasing effect on man's very existence. With this in mind, we shall emphasize scientific projection so that men of every walk in life may derive the exhilarating experience of the look-see into their wondrous future which only science can provide.

b. spencer isbell
editor

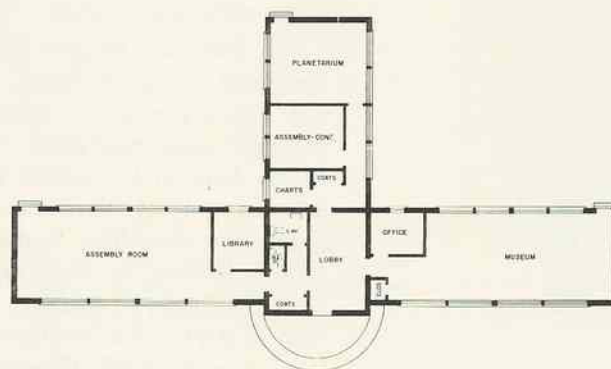
RCAA future observatory
... artist's conception



SPACE JOURNAL is dedicated to the astro-sciences, to the men of yesterday, today and tomorrow who strive, through science, to widen the horizons of knowledge that we may learn to live and understand life better.

Science has been referred to as a "great antidote to the poison of enthusiasm and superstition." We believe with eminent philosopher James R. Newman that the time has come when "an ailing world would do well to reach for the right bottle in the medicine cabinet."

The Rocket City Astronomical Association, sponsor of SPACE JOURNAL is incorporated as a scientific, educational, non-political and non-profit organization. Its present board of directors includes Dr. Wernher von Braun, president; Conrad D. Swanson, vice-president; George A. Ferrell, secretary; Quincy B. Love, treasurer; and Dr. Ernst Stuhlinger, Wilhem Angele, Erwin W. Priddy, Gerhard B. Heller, and B. Spencer Isbell.



First Floor Plan

the father of astronautics

By Ralph E. Jennings



Dr. Hermann Oberth in 1923 the year his famous book, 'A Rocket To The Interplanetary Spaces' was published. This first book of astronautics is still amazingly accurate from both a technical and theoretical viewpoint.

To Hermann Oberth, pioneer of modern astronautics and renowned physicist, this first issue of the SPACE JOURNAL of the Rocket City Astronomical Association is respectfully dedicated.

The first man to give direct scholarly treatment to space flight, Prof. Oberth was also a pioneer in rocket theory and practical experimentation. In recognition of his long and unselfish labors in the advancement of the science of space flight, the American Rocket Society in 1956 presented to Prof. Oberth the G. Edward Pendray Award. The citation read in part: "The intellectual forces set in motion by Prof. Oberth are largely

responsible for the present high state of rocketry, missile technology, and astronomical research."

Prof. Oberth was born in Hermannstadt, Transylvania in 1894 and attended schools in Schaessburg, Transylvania until he was ready to enter the University in Munich in 1913. He also studied at Goettingen and Heidelberg, and in 1923 he became a professor of mathematics and physics.

He experimented with gasoline and liquid air for rocket propulsion in 1928-30 while working as an advisor to a motion picture company. Later he pursued rocket research at Vienna Technical University and Dresden. In 1941, he joined the Peenemuende group headed by Dr. Wernher von Braun. Following the war, he conducted rocket investigations privately and was employed by the Italian Navy from 1950 to 1952 in similar work.

Prof. Oberth came to Redstone Arsenal in 1955 as a consulting engineer and later transferred to the Army Ballistic Missile

Agency at Redstone as Chief of the Special Fields Section of the Research Projects Office, the position he now holds.

His publications include "Die Rakete zu den Planetenraeumen" (A Rocket to the Interplanetary Spaces) 1923; "Wege zur Raumschiffahrt" (Means for Astronautics) 1929; "Forschung und Jenseits" (Investigation and the Life to Come) 1930; "Menschen im Weltraum" (Men Into Space) 1954. The later work has been published in English by Harper & Brothers.

He is a member of the Association of German Inventers and received the Diesel Medal from that Society in 1954. He was the inspiration for the Hermann Oberth Medal, awarded yearly by the German Society for Space Research. In 1930, he received the REP-Hirsch Award from the Astronomical Society of France. He was the recipient in 1955 of the Space Flight Award of the American Astronautical Society.



This old photo shows Dr. Oberth with some experimental rocket equipment he designed and tested in 1918.

where are we going?

By Wernher von Braun

technical director
army ballistic missile agency
huntsville, alabama

IN THE FALL OF 1945, shortly after my arrival in the United States, I became ill and was sent to William Beaumont Army Hospital in El Paso, Texas. The doctors said I had hepatitis and prescribed a fatless diet and several weeks of complete rest.

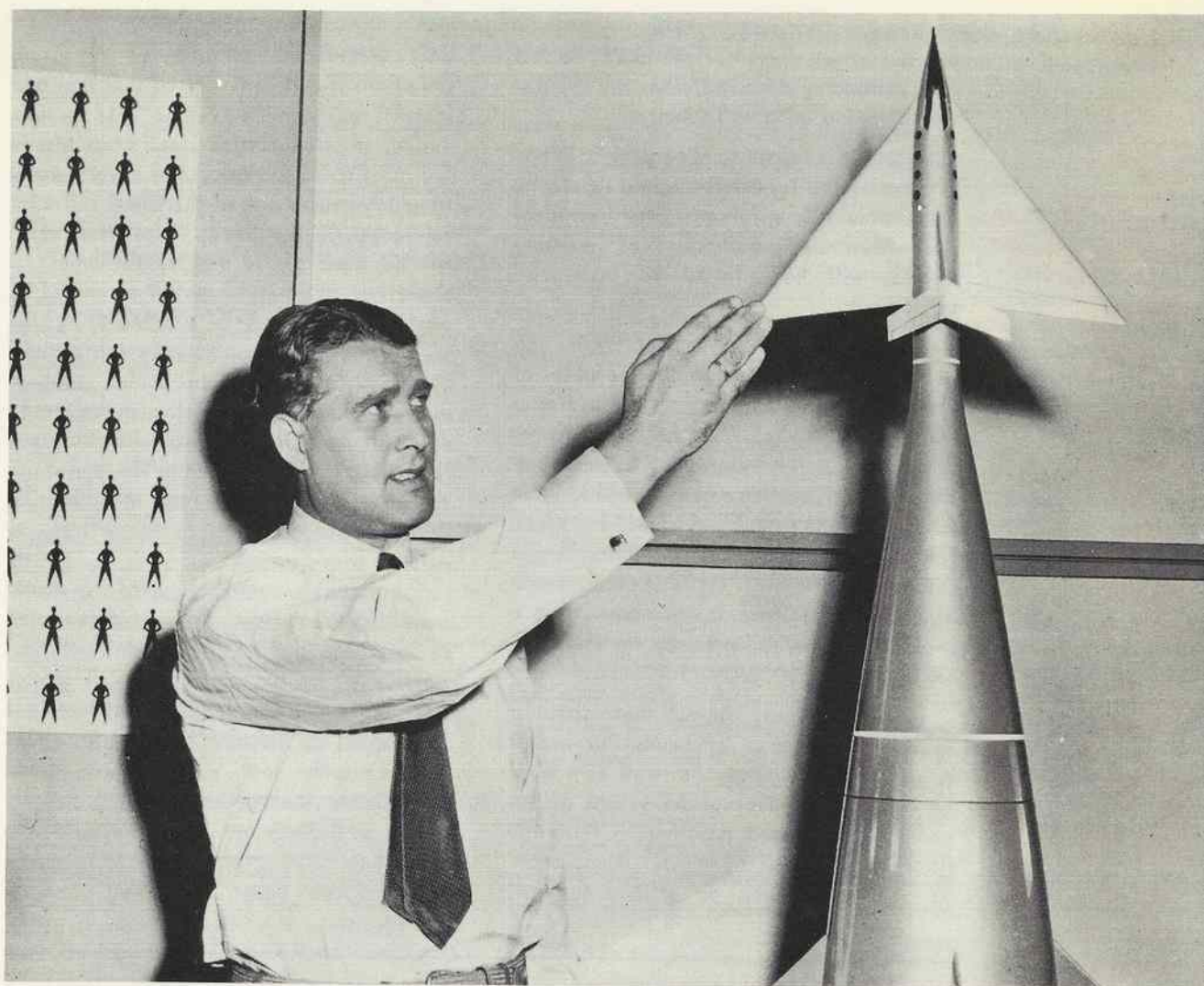
My bed neighbor in the hepatitis ward was a young corporal. His home was a ranch near El Paso, and he had just returned from the war in the Pacific. We became good friends and used to stroll through the hospital's endless covered walkways while he mercilessly destroyed my long cherished illusions about the pleasant and carefree life in the South Sea island paradise. One evening we were standing at the hospital fence watching the sun, beyond the tremendous expanses of desert, set on the Sacramento Mountains. The range was well over a hundred miles distant, but in the clear desert air it looked as if it were but a stone's throw away. To my continental eyes, accustomed to the verdant valleys and hills of central Europe, the sight was overwhelming and grandiose, but at the same time I felt in my heart that I would find it very difficult ever to develop a genuine emotional attachment to such a merciless landscape which, while unable to support more than a mere trace of vegetation, dwarfed man by its very expanse.

It was obvious that my friend the Texas corporal did not share my hidden sentiments in the least. He was visibly moved

by the colorful spectacle. At last I ventured a carefully veiled question. I wanted to find out what in this desolate landscape it was that could make a man feel homesick for it. His reply was simple and exhaustive: "I want to see where I am going."

I have often thought of these wonderful words. In our daily labors as engineers engaged in the business of building bigger and better rockets, most of us live as if we were in a fog. We do not see where we are going. We proudly declare that our rockets will soon conquer outer space for man. Our work is moving along at a fast clip; we derive great personal satisfaction from our progress, and every day brings us closer to the realization of our cherished dream: space flight. But how many of us ever bother to take a look at the grandiose scenery which we are about to open as a new theater of man's activity? And yet, all we have to do is to look up to the heavens on a starry night.

Astronomy is as old as mankind itself. Celestial events such as solar and lunar eclipses were regarded by ancient man as feats of demons. Later, with the rise of the great religions, they were interpreted as manifestations of God's omnipresence and universal rule. As early as 4000 B.C., skillful astronomers began to predict eclipses with astounding accuracy. This demonstrated ability of astronomers to predict certain events of the future gave birth to astronomy's illegitimate child, astrology, the protagonists of which ven-



Dr. von Braun with a model of his four-stage space ship in Walt Disney's Hollywood Studio during filming of "Man In Space."

tured with their predictions into non-celestial spheres.

Until the Middle Ages, a man could make a good living as an astrologer, but with astronomy alone he could not. This is the simple reason behind the strange fact that many of the world's greatest astronomers held remunerative jobs as Royal Court Astrologers. With the advent of the Renaissance and the Age of Enlightenment, astrology fell into disgrace. Astronomy as a science was purified of superstitious beliefs and hocuspo-

cus, but astronomers became poor. To this day, astronomy deservedly has the reputation of being a "poor" science.

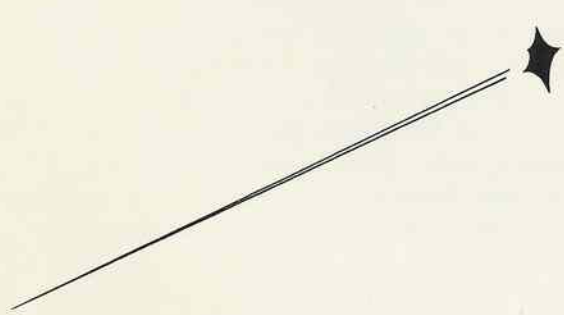
Rocketry is about to change this. When artificial satellites begin circling the earth, astronomical laws, hitherto used exclusively to describe the motions of heavenly bodies, will be applied to man-made equipment.

Astronomical observations will be needed not only to determine the paths of comets, but also to check on the performance of rocket guidance systems. Astrophysical research related to cosmic and other radiation will be heavily called upon to resolve the remaining questions which require answers before man himself can set out on his travels through outer space. That "poor" science, astronomy, needs a shot in the arm to be ready for the coming age of rocket power.

Thus it was only logical that, about a year ago, a group of Huntsville rocket scientists and engineers, as well as a number of business people and youths of the community, banded together to form the Rocket City Astronomical Association. We had no money, no official support,

only unbounded enthusiasm. Generous donations from Huntsville citizens and business firms permitted us to take action. Today, the Association owns atop Monte Sano a fine observatory, the silvery dome of which houses one of the finest reflector telescopes in the South. Now that much of the work of its own establishment is done, our Association has set as one of its objectives the task of administering the shot in the arm for astronomy and related sciences. With this particular goal in mind we have launched this magazine to acquaint interested persons with the problems that must be faced, the questions that must be answered, and the direction in which we must go in our efforts to achieve space travel.

The valuable contributions of the young people in the formation of our Association is in itself significant. Today's "teen-agers" will be the space pilots of tomorrow, and youngsters have always had that keen sense for the essential that grownups so frequently lack. The future space pilots want to know where they will be going, and they are well aware of the fact that outer space is an awfully big place — even bigger than Texas.



STARFIRE

He sits stiff-boned and spreads his age
Before the glow of silver night,
And squints a comet's pilgrimage
Into his cold and clouding sight.

You count it bad to see him so,
An old man, sad with wander-lust?
I count it good to see him so,
A child who plays in silver dust.

—Yewell Lybrand

why conquer space?

By Fred L. Whipple

chairman, dept. of astronomy
harvard university

MY PERSONAL REASONS for wishing to see man in space are at least fourfold.

Probably the greatest motivation is pure curiosity, wondering what lies beyond the next range of hills. I do not think that it is necessary to justify this as a sound reason. Most of man's progress from his Simian ancestry has come about through the fact that he is more intelligently curious than any of the lesser animals.

A more easily justified reason is, of course, the enormous impetus to science that will be made not only when man has crossed the space frontier but also when he is in the process of crossing it. Progress in science leads not only to progress in material benefits to mankind, but also to the possibility of a greater number of *Homo sapiens* inhabiting the universe. When I contemplate the astronomical gains to be attained by observations from a satellite station, or a station on the moon, or explorers on Mars, the scientist in me leaps into an excited state. So far, astronomers have been studying the universe by radiations from only a small crack in the total spectrum of electro-magnetic radiation, extending from the radio region to heat radiation, light, ultra-violet, x-rays, etc. The most interesting radiations of most astronomical objects lie in the ultra-violet, forever hidden from us on earth by the opaque wall of our atmosphere. The scientific answers that will come out of space travel will include not only the practical ones about solar radiations, cosmic rays, weather prediction, and effects on our earth, but basic and fundamental facts about the origin of our earth, the origin

of the sun, and the origin of the universe itself.

In the third place, I feel that the level of a culture from the historical viewpoint is measured largely by its technological achievements. The monuments that the ancient Egyptians left behind have made us appreciate the power of their civilization as we would never have appreciated it otherwise. The nation or culture that first sends a ship into space successfully will be marked for all time in the history of the world as a technological leader. I grant that this will do us individually very little good, but the individual human being, with few exceptions, likes to feel that he is making a permanent mark in history. Now here is an opportunity for us to make a mark that will never be forgotten as long as a civilized culture remains on the earth.

But my fourth and probably most fundamental argument for space travel is that it represents man's conquest over nature. I personally resent the confinement that gravity represents in holding us to this third-rate planet. Insofar as man controls nature, he also controls the destiny of man. There are those who will argue that man's power to control nature is overshadowed by his power to destroy man. I do not think that historical facts will bear out this argument. Every step that man has made in developing further progress in "mind over matter" has been to man's material benefit. By conquering space, man makes one more step towards insuring immortality for the race, if not for the individual.

some future astronautical considerations

By Hermann Oberth

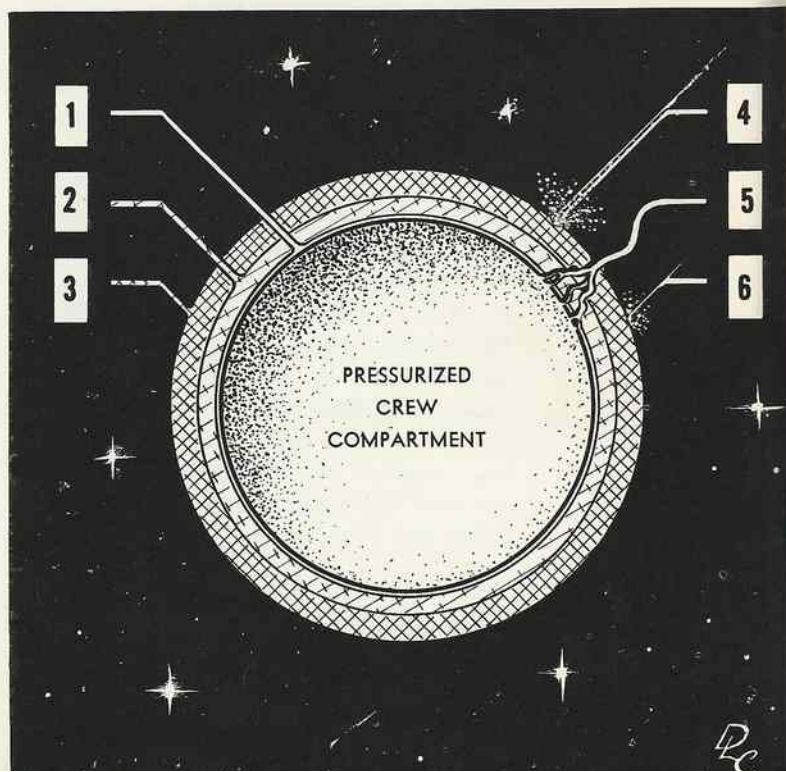
THE FIRST MAN-MADE earth satellite will soon circle the earth. This satellite, and succeeding ones, will be small (not much larger than a basketball), and will carry nothing more than a few instruments. Larger satellites, equipped with elaborate automatic instrumentation, will follow, and by means of ultra-high-frequency radio, will transmit information to the earth.

Even now, experiments are being conducted at Randolph Air Force Base, Texas to ascertain what the human body can withstand. From these experiments, engineers will determine those points in the construction of ferry rockets and manned satellites which will require special attention. This work will be completed in five to ten years.

The next step forward will depend on information concerning cosmic rays and cosmic dust which we shall have gained from unmanned satellites. Space technique can then follow either of two courses. I should like to call these "the course of the thick walls," and "the course of the thin walls." Space travel will be possible in either case.

THICK WALL TECHNIQUE

- | | |
|-------------------------|------------------|
| 1. BERYLLIUM — 1/2 INCH | 4. SMALL METEORS |
| 2. ALUMINUM — 9 INCHES | 5. COSMIC RAYS |
| 3. LEAD — 12 INCHES | 6. COSMIC DUST |





THIN WALL TECHNIQUE

- | | |
|--------------------|------------------|
| 1. SPACE SHIP WALL | 4. SMALL METEORS |
| 2. EMPTY SPACE | 5. COSMIC RAYS |
| 3. OUTER SHELL | 6. COSMIC DUST |

On earth there are people who live 9,000 feet (and, of course, even higher) above sea level. If we consider the 9,000-foot altitude as an example, the protection afforded these people from cosmic rays and dust by the atmosphere above them would be duplicated in a space vehicle by a layer of liquid air seven meters thick. Naturally, it will not be necessary to use liquid air as a protective layer, since the same effect can be obtained with a one-foot-thick outer shell of lead over a nine-inch-thick shell of aluminum. A third, or

innermost, shell consisting of one-half inch beryllium will complete the effect. Observation ports will also consist of three layers. Beginning with the outermost, or exterior, layer, there will be foot-thick flint glass, then a nine-inch layer of crown glass, and finally, one-half inch of plexi-glass. The space traveler could spend all of his life in such a protected area, without danger from cosmic rays and dust. This is the course which I call "the course of thick walls," a course which, I hope, will not be necessary, since the human body may very well be able to withstand cosmic rays.

If the human body is able to withstand these rays, the space vehicle's walls can be made of very thin and light material, so that few "secondary" rays would be encountered. For protection against cosmic dust, the vehicle walls may be constructed along the lines suggested by Dr. von Braun (a protective shell placed around the whole at a distance of one or two inches). When cosmic particles strike this outer shell their high speed will cause most of them to heat and evaporate. The diminished force of the remaining particles will not be sufficient to damage the inner or actual vehicle wall. This will be the technique of "the thin walls."

Thus, astronautical technique will take one of the two following courses:

1) In the case of the thin walls, construction materials will be obtained right from the earth, and large orbital space stations will be built. Perhaps large mirrors of metal foil will be used to influence the earth's climate. Soon electrical space ships, such as those suggested by me in 1928 and further developed by Dr. Ernst Stuhlinger, will be built. These will not be launchable from the earth, but will be capable of leaving an orbital station with ease. They will use little fuel, and with them we shall easily be able to rise to 22,000 miles. A station orbiting at this altitude will complete its path once each day, and could be controlled to remain over the same spot on the earth continually.

Large telescopes could keep an accurate "eye" on the earth in order to ascertain, for instance, that countries are actually keeping their disarmament promises; or, photographs could be obtained to counter Russian propaganda concerning so-called benefits to be derived from the Russian way of life. These stations could also serve television by acting as reflective relay stations for television waves. Likewise, communications will be improved, in that radio waves can be beamed and concentrated, thus allowing literally thousands of messages to be transmitted and received at the same time. In addition to this we can carry on many scientific experiments, and last, but certainly not least, we shall be able to reach other heavenly bodies with our electric space ships.

2) On the other hand, space technique will take an entirely different course should the human body prove incapable of withstanding cosmic rays for periods of little more than an hour. This should be the minimum time, since the human body can withstand X-rays which are ten times as strong as cosmic rays for a duration of at least 20 minutes. In this case, space vehicles with small, thick-walled cabins will be launched, and we shall try as quickly as possible to build an atomic powered electric space ship with which to obtain materials from the moon. We might even bring an asteroid into an orbital path around the earth, and get our materials from it. These materials would be used for the protective walls of any further space shelters for men.

The second course will not be as simple as the first course mentioned, but in any case, I think that by the year 2,000 we shall have developed space travel techniques.

"Common Sense is that layer of prejudices laid down in the mind prior to the age of 18."

—Albert Einstein

outlook to space travel

By Ernst Stuhlingerdirector, research projects office
army ballistics missile agency

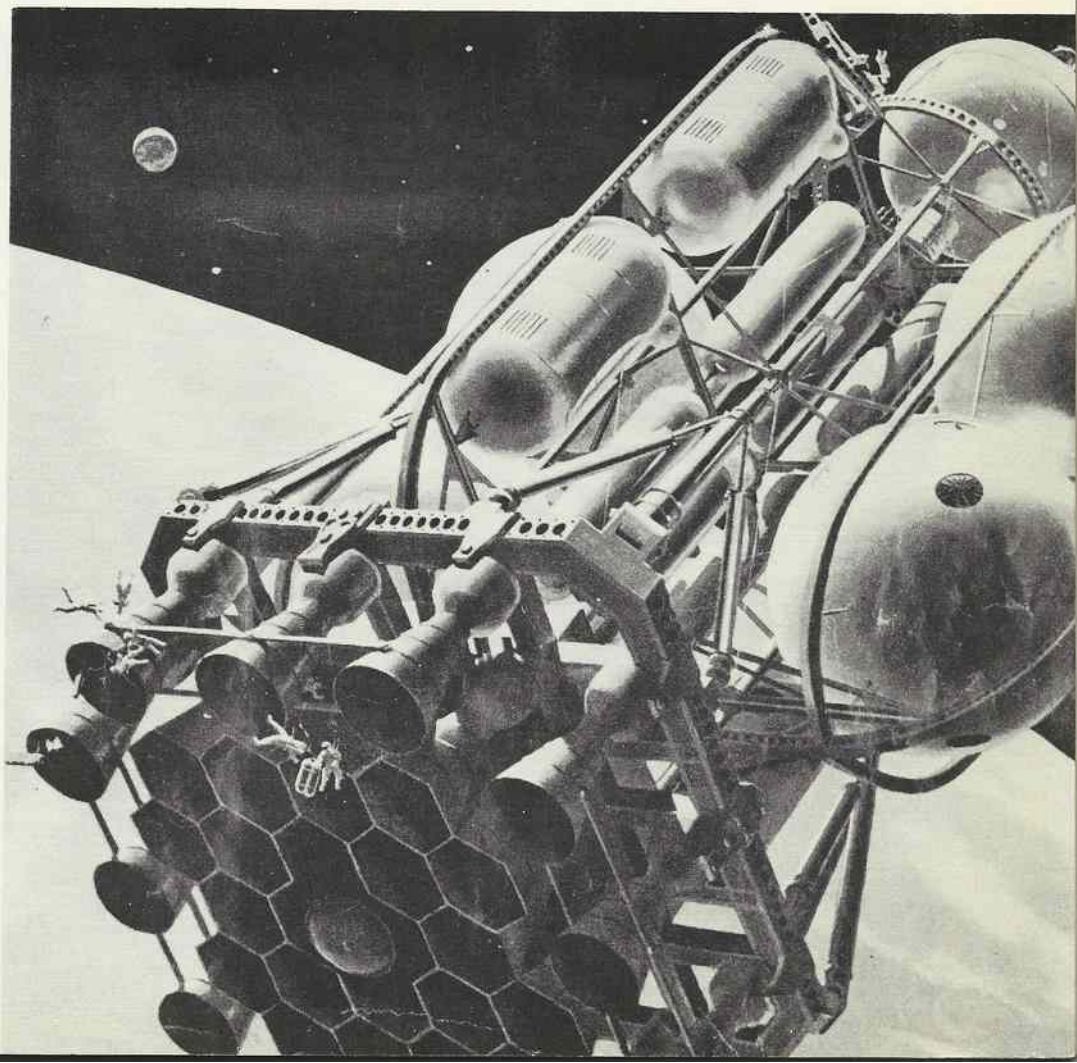
WE CAN IMAGINE that Christopher Columbus must have felt the same burning challenge to discover new lands as do the prospective space travelers of today. However, there is one important difference between the two: Columbus had the ships but did not know where he was going; the modern space traveler knows exactly where he wants to go — to the planet Mars — but he lacks the transportation.

This need not be the case, however. Although we do not have a space ship yet, we have a fairly clear idea of how an interplanetary vehicle would work and how it must be built.

We know of only one physical principle which provides the practical means to propel a vehicle through empty space; that, of course, is the rocket principle. The possibility of interplanetary travel with rocket motors was recognized decades ago. The names of three brilliant men mark the beginning of space travel: Prof. Goddard, an American, Prof. Ziolkovsky, a Russian, and Prof. Oberth, a German. But only after the first large rocket-driven guided missiles had been developed, did we gain enough experience to make realistic design studies of a space vehicle. During the last few years, a number of articles and books on space travel have been pub-

FIGURE 1

Von Braun's proposed outer space vehicle which is carried as part of the payload in his space ship and assembled on the satellite space station.



lished. By far the most realistic studies were made by Dr. Wernher von Braun, the developer of the V-2 Rocket (Fig. 1). His newest concept of a space ship for a round trip to Mars is a vehicle of about 1700 tons initial weight, with 35 tons of payload. The propellants are nitric acid and hydrazine. Two such ships, carrying a crew of twelve men, would make the expedition. The travel time to Mars would be 260 days. The total time of the Mars expedition, however, includes a waiting period on Mars. This period is determined by the fact that the return trip must be accurately timed in order that the ship meets the earth at a predetermined point on its ellipse around the sun. All told, the expedition time would be a little more than two and one-half years.

The remarkable fact about Dr. von Braun's very detailed Mars project is that it is based entirely on present technical and scientific knowledge. Any speculations concerning future discoveries are strictly avoided.

It would be hopeless to try to design a space ship which takes off from the surface of the earth, overcomes the atmospheric drag and the earth's gravity, covers the long distance between earth and Mars, makes a safe and gentle landing on the uninhabited planet, and is still prepared and equipped to make the return trip to its home base. Fortunately, this complex transportation problem can be handled with ease by subdividing the voyage into several phases. Thus, the first step to interplanetary travel will be the establishment of a space station, orbiting around the earth as a satellite at an altitude of about 1000 miles above its surface (Fig. 2). Commuter traffic from the earth to this space satellite will be made with large, three-stage rockets. The winged nose section of these rockets, a sort of fourth stage, is used for the return trip from the satellite to earth (Fig. 3).

The second part of an interplanetary trip covers the long stretch from the satellite station to an orbit around Mars.

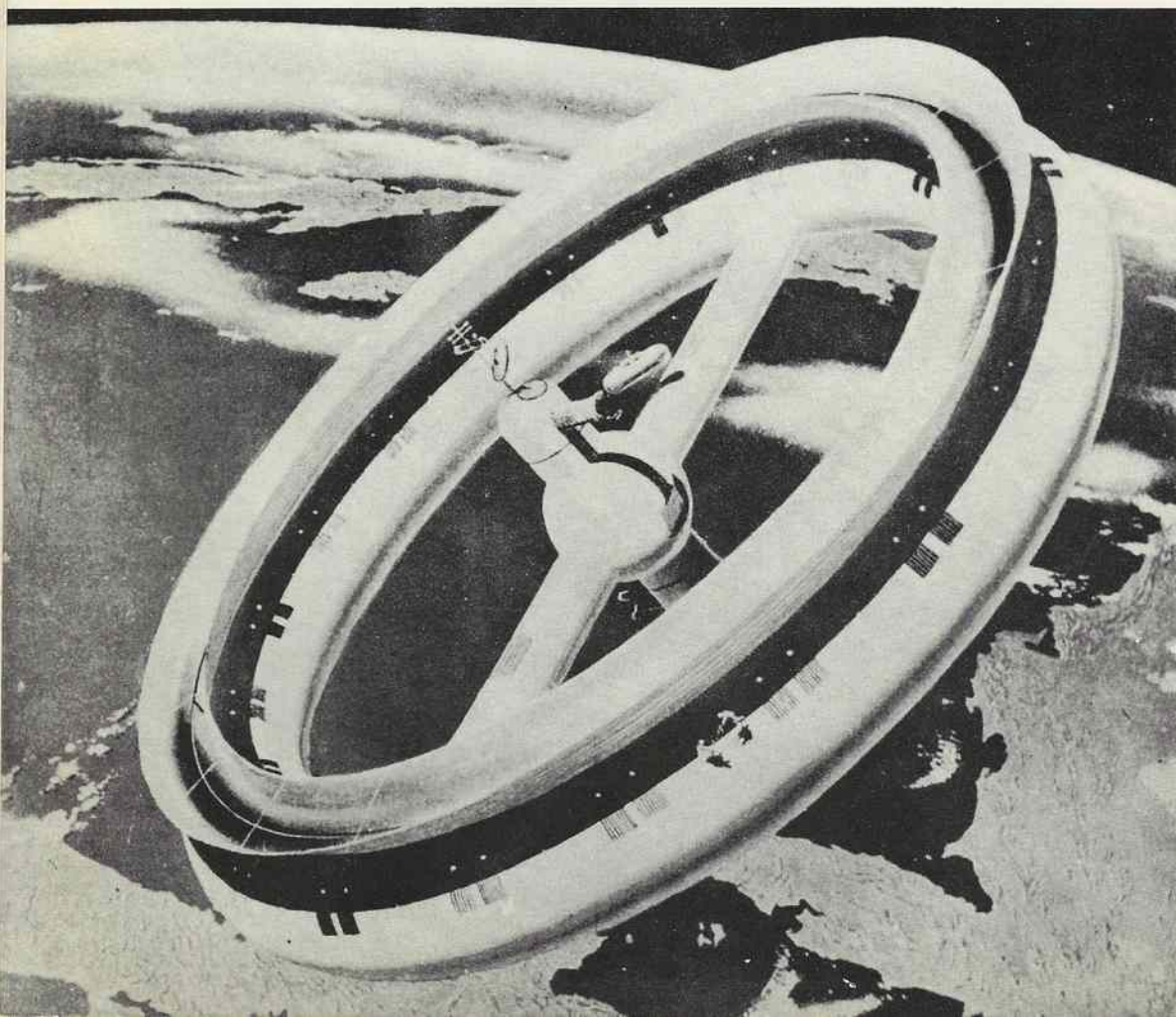
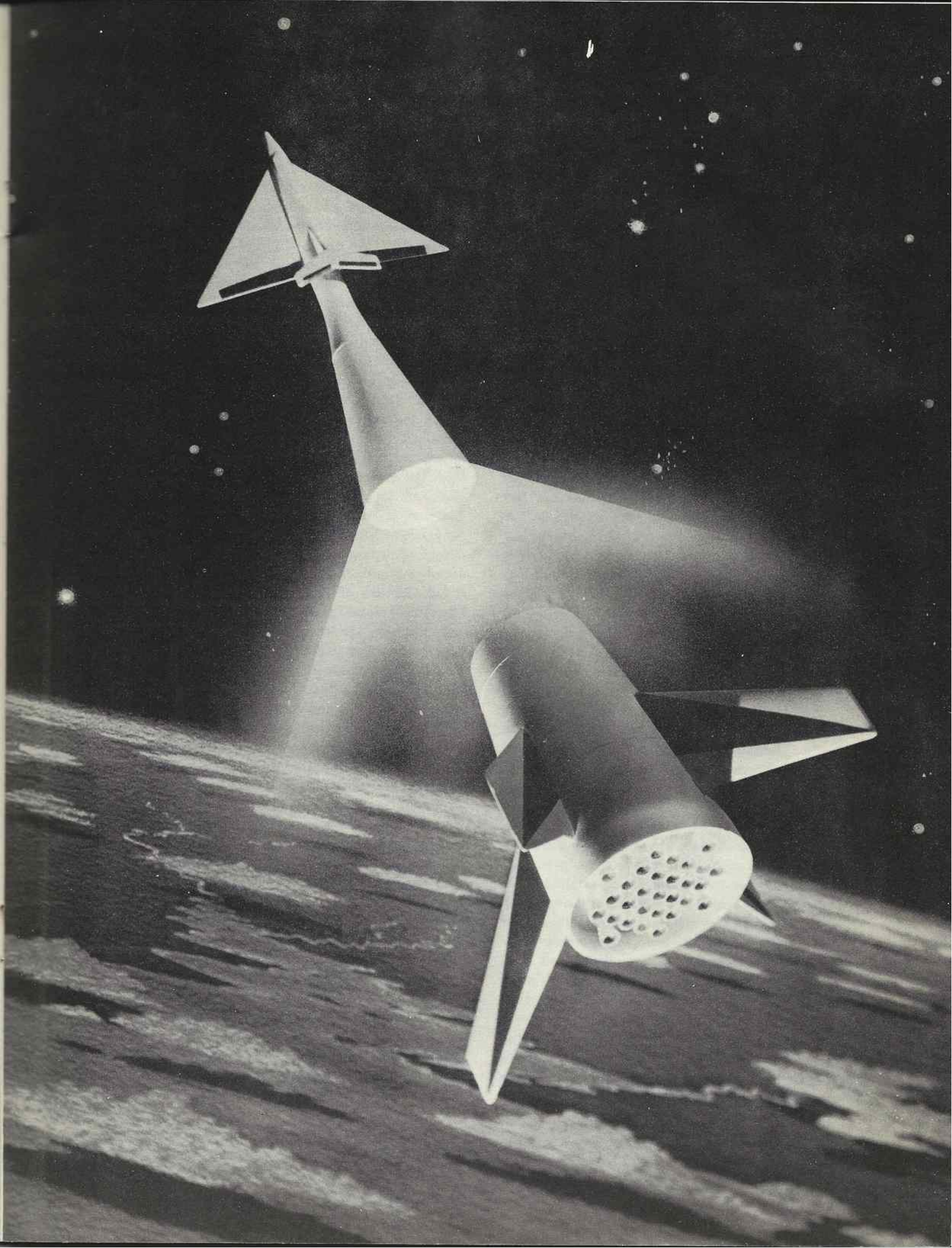


FIGURE 2

Von Braun's 1000-mile-orbit satellite space station, the first step to interplanetary travel.

FIGURE 3

The first stage of von Braun's four-stage space ship drops away and the second stage propulsion unit takes over. Note the winged fourth stage which is designed for the return trip from the satellite to earth.



The space ship, traveling from the earth satellite toward Mars, will not land on Mars but will end its voyage in a circular orbit about 600 miles above the Martian surface.

For the third phase of the trip, a winged landing craft will be detached from the orbiting ship. It will reduce its orbiting speed by rocket power and enter a downward trajectory. After a long glide through the Martian atmosphere, it will land either on skids like a glider, or by parachute and counter rockets.

At the end of the exploration period on Mars, the landing boat will take off from the planet by rocket power and will join the space ship, which is still orbiting about the planet at an altitude of 600 miles. The crew will transfer back to the ship and will make the return trip to the earth satellite. The last portion of the expedition, the hop from the satellite to earth, will be done by one of the winged fourth stages of the commuter rockets.

The longest part of the voyage will be the section between the satellite orbit around the earth and the orbit around Mars. The space ship will be tailor-made for the conditions prevailing during this voyage. Quarters for the crew will be sealed and provided with an artificial atmosphere. The ship will not be streamlined since it travels only through perfect vacuum. The thrust of the rocket motors need not lift the vehicle against the gravity forces, since these forces are exactly balanced by centrifugal forces in any object that moves around in a satellite orbit. Even a relatively low thrust will enable the ship to leave its original satellite orbit and to enter into a trajectory which finally approaches the Martian ellipse.

The space ship will be assembled in the satellite orbit close to the space station. All components of the ship, its equipment, and the fuel needed for the round trip, must be carried into the satellite orbit by the three-stage commuter rockets. These carrier rockets must overcome the earth's

gravity and atmospheric drag, and they must impart to their payloads the orbital velocity of about five miles per second. This earth-orbit operation proves to be the most costly part of the entire Mars expedition. For every pound of payload, about 160 pounds of take-off weight must be invested in the commuter rockets. The space ship designer will, therefore, make the greatest effort to build his vehicle as light as possible. Furthermore, he will plan the expedition in such a way that any components which become unnecessary during the voyage, such as empty tanks, containers, supports, and even instrumentation, can be disposed of immediately. Ship and crew should finally arrive back in the earth satellite orbit with a bare minimum of equipment and reserves.

By far the largest part of the take-off weight of such a space ship will be made up of the propellants. The attempt to reduce the mass of a space ship, therefore, leads immediately to an investigation of its propulsion system. The basic rocket equations show that the performance of a rocket engine is mainly determined by the exhaust velocity of the gases from the combustion chamber. In rocket engines based on a chemical reaction between the propellants, the exhaust velocity is intimately related to the temperature inside the combustion chamber. The temperatures at which modern combustion chambers operate are close to the maximum temperatures which can be expected from chemical reactions. There is not much hope that the performance of chemical rocket motors can be improved much beyond the point at which we have arrived today.

It seems, however, that another type of reaction motor holds some promise for use in an interplanetary vehicle. If the velocity of the exhaust particles is not produced by the heat energy of a chemical reaction, but by electrical fields, much higher exhaust velocities can be obtained. The amount of electrical energy

which can be imparted to a given mass of exhaust material is much greater than the energy which can be given to the same mass by a chemical reaction. Also, the electrical field would direct the exhaust particles in such a way that they would not strike the thrust chamber walls. Hence, the wall heating problem in an electrical engine would be considerably less than in a chemical engine.

An electrical propulsion system would require the ionization of a suitable propellant material. It would also require a primary power source, the conversion of the primary power into electric power, and a thrust chamber in which the electric power is applied to accelerate the ions.

A detailed study of the feasibility of an electrical propulsion system has already been made. This study has proved that an electrical system is feasible and that an electrically propelled space ship would be much lighter than a ship with a chemical propulsion system. The electrical system would, however, be definitely restricted to space vehicles traveling between satellite orbits because the thrust of an electrical propulsion system would always be so small that it could never lift the vehicle from the surface of a planet against the gravity forces. The propulsion system would operate continuously, first accelerating the ship, and later decelerating it by reversal of the thrust direction. In the Mars trip, for instance, the ship's velocity would increase steadily up to the point of thrust reversal and then decrease to such an amount that, upon the approach to Mars, the ship would be captured by the planet's gravitational field. The primary power source must generate power throughout the time the ship is traveling. The total length of travel for a round trip to Mars will be of the order of two years.

The basic assumptions underlying the design of the electrical space ship are a payload of 150 tons and an acceleration of about $10^{-4}g$. The payload includes the crew, with equipment and sufficient

supplies of oxygen, water, food, living quarters, observation instruments, and the landing craft with equipment for the crew to subsist on Mars. The minimum acceleration must be great enough to complete the round trip in a reasonable time and to allow the expected corrective maneuvers during flight. A nuclear reactor is chosen for a primary power source. It is a "fast" reactor for weight-saving reasons, containing twelve tons of uranium. Its U-235 content is enriched to about 1.7%. The reactor heat is absorbed by a cooling system employing sodium-potassium as a coolant.

The reactor is located at a point about 250 feet away from the living quarters. It is shielded by a thick layer of beryllium and a sheet of boron so that the strong neutron and gamma radiations are kept away from the living quarters. The heat energy contained in the sodium-potassium is transferred to a working fluid (silicon oil) in the heat exchanger. Steam produced in the heat exchanger drives a turbine which is coupled to an electric generator. The steam leaving the turbine enters a large radiation cooler where it condenses again. From there, the fluid is pumped back to the heat exchanger.

The material best suited for the propellant is one that can be ionized easily and has a high yield. An alkaline metal like rubidium or cesium will be chosen. The atoms of these metals are ionized with almost 100% efficiency when they strike a hot surface of platinum foil. A temperature of about $200^{\circ}C$ is enough to produce a sufficient vapor pressure of the alkaline element. The vapor enters an ionization chamber containing hot platinum grids, and the ions are extracted from the chamber by an electric field. This field accelerates the ions in the thrust chamber to a velocity of about 50 miles per second. They leave the propulsion system in a steady flow, representing an electric current. The electric power, as determined by this current and the potent-

ial difference through which the ions pass in the thrust chamber, must be provided by the electric generator.

The maximum current density which can be obtained in the thrust chamber is limited by space charge effects. These effects also influence the formation of the jet of ions which extends from the thrust chamber into empty space. An unlimited beam of ions — even a beam of a noticeable length in fact — would be impossible. The space charge would act back on the thrust chamber and would neutralize the accelerating field.

In order to produce and maintain a continuous flow of particles out of the propulsion system, the ions must be electrically neutralized soon after they leave the thrust chamber. Fortunately, this neutralization can be achieved rather easily. When the alkaline atoms come in contact with the heated platinum grid, one negative electron jumps off every atom, leaving a positive ion behind. The electrons enter into the platinum foil. These electrons must be expelled from the ship — otherwise, the ship would quickly assume a strong negative charge which would prevent any further expulsion of positive ions through the thrust chamber. The natural way to neutralize the ions is to expel the electrons in the immediate vicinity of the ion thrust chambers. The two beams mix shortly behind the end of the thrust chambers, where the electrons and ions form a neutral plasma. In this way, the strong space charge of the exhaust jet is avoided.

An expulsion chamber for electrons consists of a hot filament which emits electrons, and a field of about 200 volts potential difference. One ion thrust chamber has a diameter of about one inch, and a total of many thousand thrust chambers will be needed to produce the thrust required for a space ship. The ion chambers and the electron chambers are tightly packed so that neutralization of the ions occurs at a distance of about one inch

behind the thrust chambers. It is assumed that the power plant and thrust chambers are in operation during the entire trip, either accelerating or decelerating the vehicle.

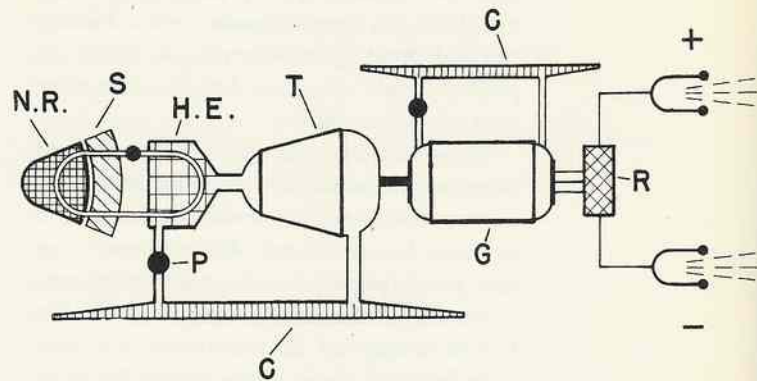


FIGURE 4

A schematic of Stuhlinger's proposed propulsion system.

A schematic of the nuclear reactor, the heat exchanger, the turbogenerator, and the ion and electron chambers is shown in Figure 4. The largest component of the propulsion system will be the radiation cooler. The optimum size of the cooler is one for which the total mass of the power generating system is a minimum, based on a given electrical power output and a given temperature of the hot steam. The figure characterizing the specific power of the power plant, measured as power output divided by the total mass, proves to be one of the decisive figures from which the design of an electrical space ship must start. This figure was found to be of the order of 0.1 kw per kg. With that figure, an assumed acceleration of at least $10^{-4}g$, and a total payload of 150 tons, the design data for a space ship capable of going to Mars and back can be derived.

The detailed study shows that for any given set of the four parameters — payload, minimum acceleration, specific

power, and destination planet — optimum values are found for propellant mass, total power, and accelerating voltage. With these optimum values, the total initial mass of the space ship is a minimum. Values different from these optimum figures would result in a heavier ship.

The following design data were determined for the ship:

Total initial mass	730 tons
Propellant mass	365 tons
Total electric power	23 megawatts
Accelerating voltage	4880 volts
Exhaust velocity	50 miles per sec.
Total thrust	110 pounds

The travel time of this ship to Mars would be a little over a year; the time for the trip back, a little less than one year. The ratio of total initial weight to payload is less than 5 to 1, which is a very favorable figure for a rocket propelled vehicle.

The structural design of the ship will take into account the absence of atmospheric drag and appreciable acceleration

forces. Structural elements will be very light. The proposed design is shown in Figure 5. It is symmetrical around the longitudinal axis, with the reactor at one end and the living quarters at the other. As soon as turbine and generator start to turn, the entire ship revolves slowly in the opposite direction. The rotation of the ship, which continues as long as the turbo-generator turns, is very desirable, because it makes the condensed fluid in the cooler flow to the outer rim, from where it can be pumped back conveniently to the heat exchanger. Also, the crew in the toroidal living quarters will sense at least a little gravity, stimulated by the centrifugal force. The thrust chamber with propellant tanks will be mounted in such a way that the thrust force always goes through the center of gravity of the entire ship. The landing craft for Mars will be attached to the thrust chamber unit, with the thrust vector pointing through its center of gravity. The thrust vector will normally be parallel to the tangent of the trajectory.

The flight path of a space ship with an electrical propulsion system differs from that of one powered by chemical rocket motors. The acceleration of an electrical ship is only a small fraction of one g. Its propellant consumption and mass ratio are smaller than in a chemically powered ship. The time of propulsion is much longer. As mentioned above, the electrical propulsion system operates during the entire trip except for a few powerless periods of short duration which are needed

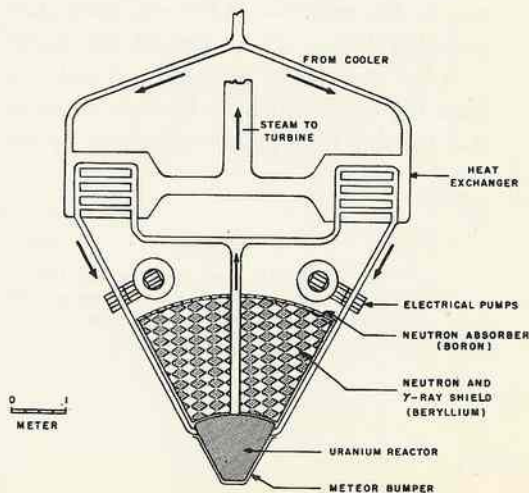
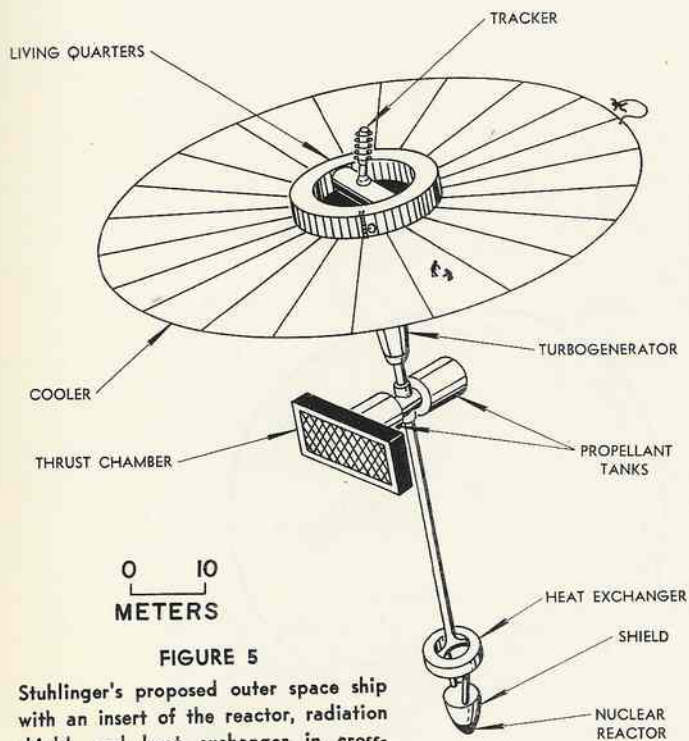
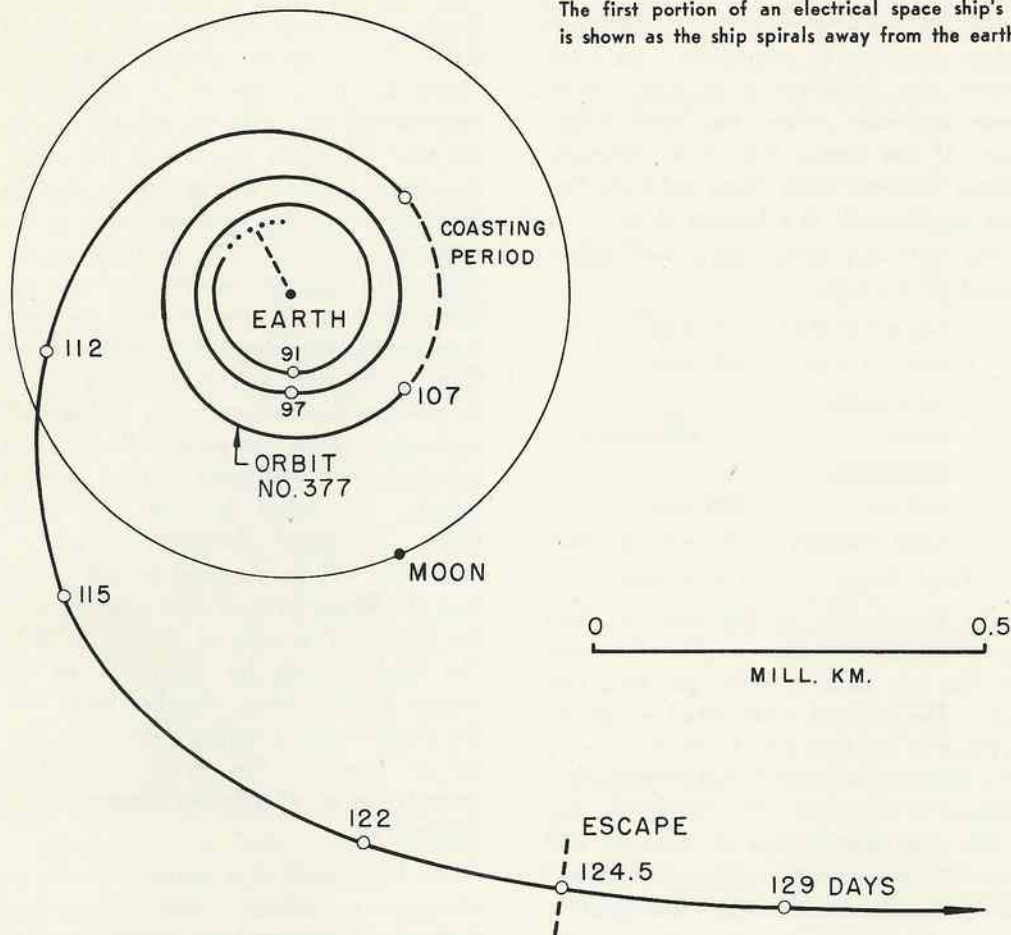


FIGURE 6

The first portion of an electrical space ship's trajectory is shown as the ship spirals away from the earth satellite.



for corrective maneuvers. The electrical ship's trajectory will not follow an elliptical path, but segments of spirals.

At first, the ship spirals around the earth (Fig. 6), and its distance from the satellite station increases very slowly (after two hours, it will not be more than 20 miles away). After one hundred days of steady spiraling, its distance from the earth will be 100,000 miles — about half-way to the moon — and it will have completed 376 revolutions around the earth.

A few days later, its speed and distance from the earth will have become so large that the ship is no longer restrained by the

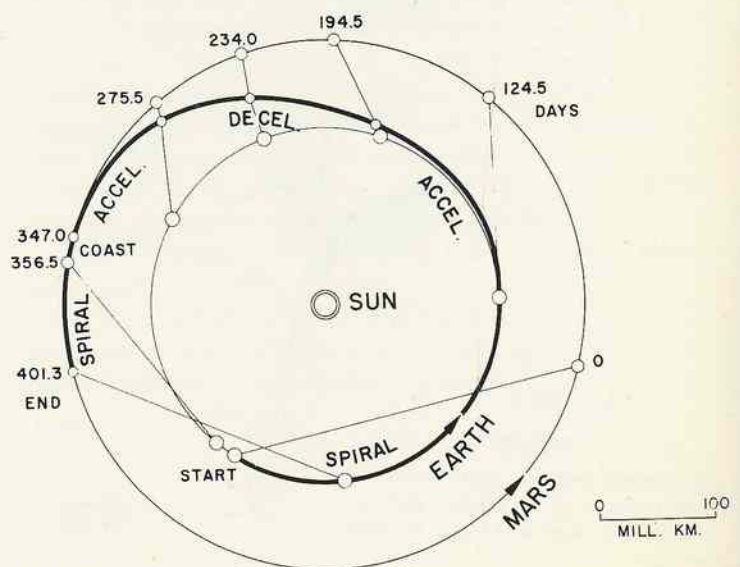


FIGURE 7

The electrical space ship moves into a large spiral around the sun some 100 days after leaving the satellite.

earth's attractive force. Its trajectory will flatten out, making a transition to a large spiral around the sun (Fig. 7).

On the 195th day, the thrust unit will be rotated through 180 degrees and the ship starts to decelerate. If it did not, it could never be captured by the Martian gravitational field. The deceleration leads the ship gradually into an inward spiral about the sun.

On the 276th day, the thrust will be switched again to acceleration, and this last maneuver carries the ship gently into the Martian ellipse. It arrives there on the 347th day. If the entire trip has been timed correctly, the ship will approach a point on the Martian ellipse where Mars is located at that time. If the ship should arrive too late or too soon, it will merely turn its thrust vector slowly towards the sun or away from the sun. By doing this, it manages to stay in the Martian ellipse with overspeed or underspeed. In the first case, it will approach Mars from the rear; in the second, it will be approached

by Mars. The approach of the ship to the Martian ellipse and the capture are shown in Figure 8. A few thrust maneuvers, as indicated in the figure, will be necessary to direct the ship into a spiral around the planet. Otherwise, it would crash on Mars or pass the planet in a hyperbolic trajectory.

On the 402nd day, the ship will have descended on its spiral to an altitude of 600 miles above the surface of Mars. The crew shuts off the motor and prepares for the exploration of the planet. The correct time to start the return trip will be 472 days away. This long waiting period gives the crew ample time to observe Mars closely by telescope and rocket probes, to descend to its barren surface with a winged landing craft, to explore its landscape and study its mysteries, and finally to return to the orbiting space ship by means of the rocket-powered central part of the landing craft.

The trip back to earth will be similar to the earth-Mars trip. It will begin with

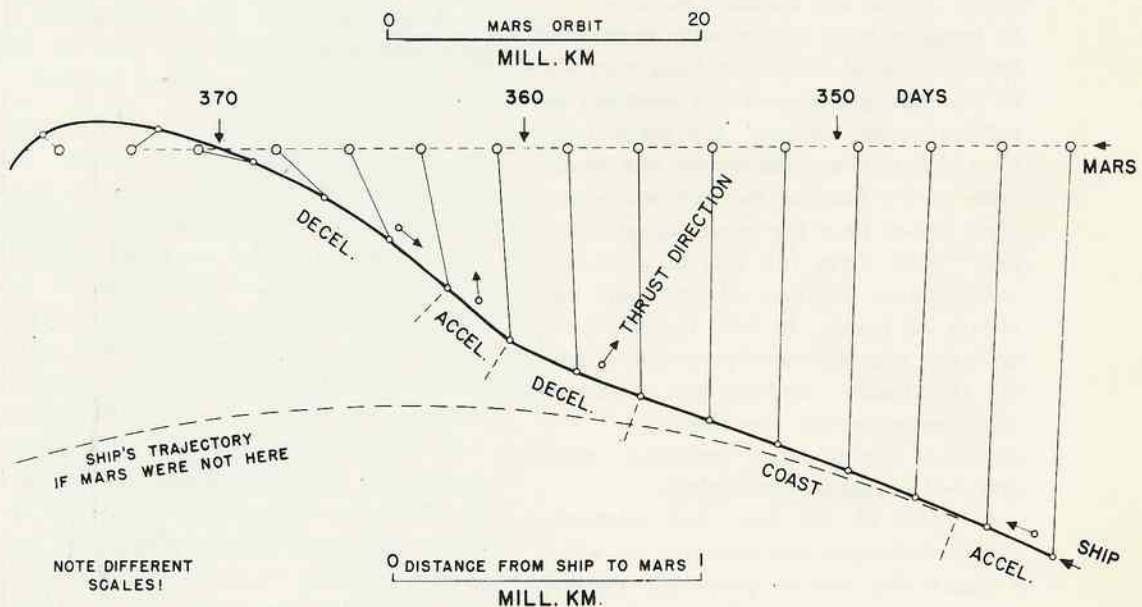


FIGURE 8

The electrical space ship approaches Mars and is "captured" by the planet's gravitational field.

42 days of spiraling around the planet. Then, a decelerating period follows which puts the ship into an inward spiral around the sun. Subsequent acceleration adapts this spiral to the earth's ellipse. A few capture maneuvers follow, and a narrow spiral around the earth ends the long trip. After a total time of three and a quarter years, the crew arrives again in the orbit of the satellite station. A short shuttle trip takes them down to earth.

The continuous operation of the propulsion system makes the guidance of the space ship easy. At no time will there be a need for unusual accuracy of pre-settings or aiming. Corrections can be introduced any time as soon as the trend toward a deviation becomes noticeable. During the spiraling around the earth or Mars, for example, a period of powerless orbiting can be introduced in case a time delay should be needed. If the ship should be late, it can gain time during the spiraling phase by opening the throttle a little more.

Navigation likewise will not impose insurmountable problems. The ship will keep a constant watch of the earth, Mars, Venus, Jupiter and the sun. The directions to these celestial bodies with respect to the direction of one of the fixed stars will be continually measured and recorded by automatic star trackers. The actual positions of the sun and the planets in a coordinate system fixed to the stars are accurately known from the astronomical almanac. With these two sets of data, the instantaneous position of the ship can always be found. In fact, the ship's coordinates are continuously computed from the star tracker readings and compared with the expected coordinates. If any deviation should occur, corrective measures will be taken immediately.

In spite of the fact that relatively simple techniques are available by which a space ship can be propelled, guided, and navigated through interplanetary space, a number of questions remain which

might appear much more difficult to solve. Meteors and cosmic rays present a danger unknown to earth-bound beings who are well protected by the atmospheric shield.

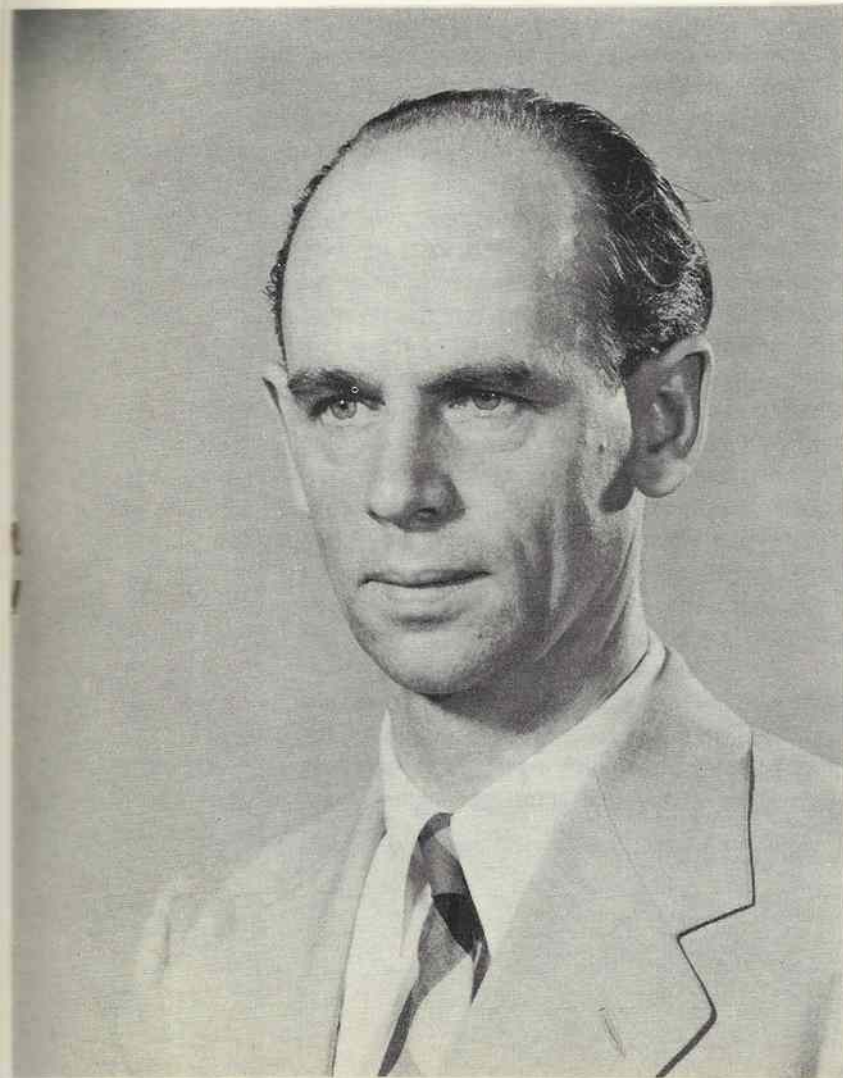
Maintaining an artificial atmosphere so human beings can live inside the living quarters and the space suits and work comfortably sounds like a tremendous problem. A total travel time of two full years duration spent in the monotonous seclusion of the ship's living quarters may seem a psychological impossibility. But things are not as bad as they might seem. Small meteors, which are frequent, can be shielded off by an absorbing bumper. It consists of a thin sheet of metal around the ship. Larger meteors are very rare. If one of them should punch through the wall of the ship, the doors of the damaged compartment close automatically, and in most cases the damage can be repaired before a real disaster develops. If a vital part of the ship's machinery should be destroyed, the crew abandons that ship and boards one of the other ships (there will be a total of about 10 ships traveling together in one expedition). If a man should be hit — well, the probability for such an accident is about comparable to the probability that a man loses his life on this earth in some kind of accident.

We still know little about the dangers of cosmic radiation in outer space. But we do know that these dangers are much smaller than previously assumed, and we may be confident that ways and means of efficient protection will be available before the first trip to Mars begins. After all, the manned satellite station will represent an excellent research laboratory to study all the effects of outer space, including weightlessness, artificial atmosphere, and life in confined quarters. By the time the first space ship leaves the satellite for Mars, its voyage will be much better prepared, in every respect and detail, than was Columbus' expedition when he started out to find this continent.

The probability of the safe return of the spacefarers to earth will be greater than for many a daring and courageous team who set out in the past seeking new lands.

The crew on an interplanetary ship will have more comfort and more space to move around in than the crew on a modern submarine. They will stay in constant contact with earth by radio and television. The men to be selected for the expedition must be of excellent health and stability. They will be persons of the scientific type who combine the love of adventure with the craving for scientific knowledge —

men who can forget their personal desires in favor of the idea of a great technical and scientific achievement. Men of this nature will not mind spending two quiet years traveling on board a space ship. In his normal life, such a man always carries with him a backlog of unfinished scientific work which he cannot find the time to complete. If he is given the opportunity of two full years of undisturbed time to study and work on his pet projects, this prospect will be for him one more dream to come true when the first space ship takes off for its long voyage to Mars.



Dr. Ernst Stuhlinger

the masses of the stars

By Daniel M. Popper

chairman, dept. of astronomy
university of california

ALL THE MATTER in the universe, from the familiar objects around us—animate or inanimate—to the sun and stars and on out to the most distant galaxies, is composed of atoms — atoms of hydrogen, helium, oxygen, iron, uranium, and all the other elements. By a suitable definition of terms, this statement can be extended to objects consisting of "anti-matter," although there is no evidence as yet that anti-matter exists anywhere in a stable condition.

One of the fundamental facts of astronomy is that nearly all the atoms of the universe are organized into condensations of two classes. The first class is the stars (or suns) each of which is enormous compared to the earth but minute in terms of the distances between stars. The stars in turn are grouped into the second class of condensations, the galaxies, each of which is a system of billions of stars and is in turn small compared to the distances between galaxies. The amounts of matter not in stars, such as that contained in planets, comets, and interstellar gas and dust clouds, make up but a small fraction of the matter of the universe, so far as we know.

The task of the astronomer is to try to understand the universe. At present he is far from understanding why the matter in it is organized into these two types of condensation (stars and galaxies), each type being restricted to a limited range insofar as the amount of matter per object is concerned. As a matter of fact, he is still far short of a complete knowledge of the amounts of matter, or masses, of the stars of different kinds.

From the most fundamental standpoint, we should think of the mass of a star as being made up of so many atoms of hydrogen, so many of helium, so many of iron, and so on, each individual atom having a mass as determined in the physics laboratory. Although we have a fair idea, mainly from spectroscopic evidence, of the relative numbers of the different kinds of atoms in stars (the overwhelming majority are hydrogen and helium), we have no way of counting all the atoms in order to determine the mass of a star.

The only means at the astronomer's disposal of finding a star's mass is to make use of a property quite independent of its atomic make-up, namely the gravitational attraction it exerts on some other star. But we have already noted that the stars are very far apart, much too far in general to exert appreciable gravitational attraction on each other. Fortunately, however, quite a large percentage of stars exist in close pairs — binary systems. We have no clear idea of the reason for this state of affairs which must be related to the origin of the stars, but it does allow us to obtain masses for a modest number of them.

Binary-star systems may be divided in two categories: visual binaries and spectroscopic binaries. The former are so called because the two stars of the system may be seen separately. In order to be seen in this way, the two stars must not be too close together nor too far from our sun. The periods of revolution of visual binaries are typically decades or centuries. In order to obtain the masses of the components of such a system, observations of three different kinds are needed. First,

the apparent orbit of one star relative to the other must be obtained. For this purpose, visual observations of the separation and orientation of the stars must be made over a considerable fraction, if not all, of the period of revolution of the system. This is one important type of modern astronomical research where the eye of the observer has not been replaced by the photographic plate, except for the wider pairs. The second kind of observation needed is the parallax of the system, and the third is the ratio of the masses of the two stars. Both of these latter kinds are obtained by photographic measurements (with telescopes of long focal length) of the changing positions of the stars relative to a background of more distant single stars. A recent compilation by an expert in this field of research shows that the masses of the stars of only about 25 of the many known visual binaries are known with any degree of precision.

Spectroscopic binaries are systems in which the two stars are too close together to be seen separately in any telescope. The binary nature of the system is revealed by spectrographic analysis. When the two stars are of comparable brightness, the lines of both of them will be seen in the spectrum (it often requires considerable analysis to disentangle the two); furthermore, the two sets of lines will shift positions back and forth in the spectrum in step with the orbital motion. In these systems the stars are closer together than in the visual binaries, and the periods of revolution are typically days or weeks. The shifting of positions of the spectrum lines is the key that shows the stars are moving about each other, and allows us to analyze the motions, and hence obtain information about the masses of the stars. The information will be incomplete, however, unless we can tell how the orbit plane of the system is oriented relative to the line of sight. In the general case this angle of orientation must remain unknown; but in the special case

when the orbit plane is so oriented that the stars alternately get in front of each other every half revolution, then we have an eclipsing binary. Analysis of the brightness variations during eclipses allows us to obtain the orientation angle, and consequently the masses. So we see that in order to obtain the masses of the stars in such a system, we need to use two kinds of observation — spectrographic and photometric. There has been a great increase in recent years in the number and precision of photometric observations through the widespread use of photoelectric techniques. Although hundreds of eclipsing binaries have been studied, reliable masses are known for only about as many systems as in the case of the visual binaries. The reasons for the small numbers of stars for which this most fundamental of all quantities is reliably known lie chiefly in the difficulties of analysis in all but the few most favorable cases.

The results of these mass determinations show that for the great majority of the stars (the "main-sequence" stars), the mass is correlated closely with other properties, large mass going along with high surface temperature and large radius. It would seem that when the primary condensations into stars took place, the amount or mass of matter that happened to stick together pretty well determined the rest of the properties of the main-sequence stars.

But what of the other stars, not of the main sequence, such as the supergiants, the red giants, the Cepheid variables, the white dwarfs, and so on? Why are the giants and supergiants so much larger than main-sequence stars? Why are the white dwarfs so much smaller? Why do the Cepheids vary in brightness? In years past numerous answers have been proposed to such questions. Current astrophysical theory conjectures — and not without strong supporting arguments — that after a star of the main sequence has used up a large part of its internal energy source

RELATIONSHIP BETWEEN STARS

- - - POPULATION I - - -

+++ POPULATION II +++

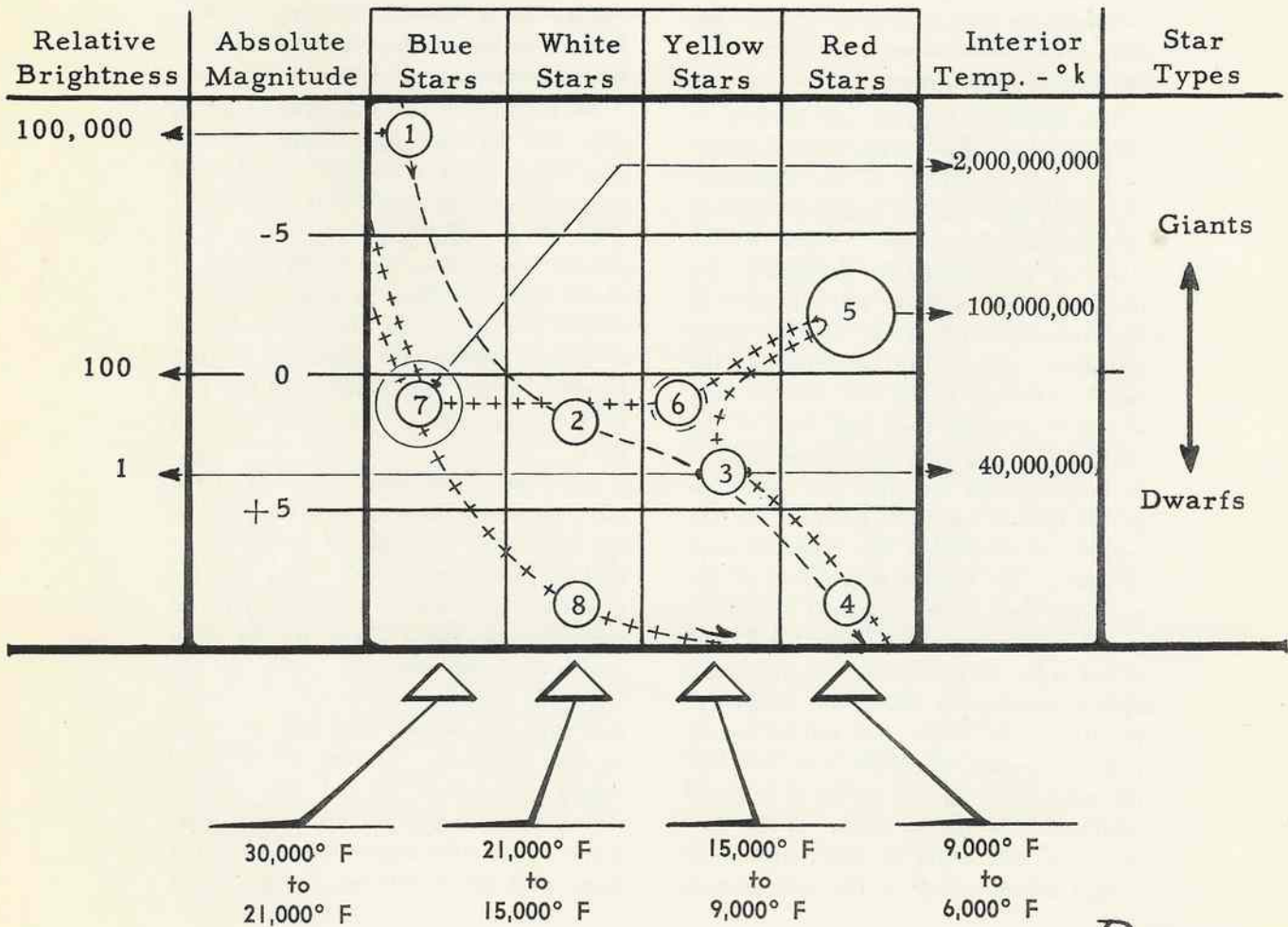
(Relatively young stars, usually found in Spiral Arms of Galaxies)

(Relatively old stars, usually found in Globular Clusters)

No.	Type	Approx Size
1	Blue Giants	4 to 10
2	—	2 to 4
3	Sun	1
4	Red Dwarfs	1/3 to 3/4

No.	Type	Approx Size
5	Red Giants	20 to 3000
6	Cepheid Variables	5 to 10
7	Novae	1/4 to 1/2*
8	White Dwarfs	1/20

Before exploding*



by converting most of the hydrogen in the deep interior into helium, it changes its structure and evolves through various stages, expanding into the giant or super-giant class, perhaps becoming a variable star for a while, and finally collapses as a white dwarf.

These are intriguing possibilities, but is there firm observational basis for them? The changes are thought to occur much too slowly for such a process to be observed in a given star; hence, evidence that is less direct must be sought. If we could obtain reliable values of the masses of stars of all the different kinds, we would remain sensibly constant through all of its changes, except perhaps during the final collapse, when it might blow off an appreciable fraction of its matter. There is, unfortunately, very little observational evidence on the masses of stars which are not of the main sequence. Such stars are relatively rare in space (except for the white dwarfs), and there just are not enough determinations of their masses to provide conclusive checks on the evolutionary theory of changes of stars from one type to another.

It is true that the three white dwarfs of which the masses are known turn out to be super-dense stars, in agreement with the theory, but their masses have probably changed, so that they cannot be compared to the masses of their possible-precursor

types of star. Thus the determination of the masses of stars not of the main sequence stands as an outstanding observational problem that needs to be attacked before astronomers can claim to understand the fundamental building blocks of the universe.

An article on the masses of the stars should, I suppose, have some numbers in it indicating what the range of masses of the stars is. We use our sun as our standard of comparison. It contains about 330,000 times as much matter as the earth which, for those who like large numbers, contains six thousand million million million tons. The most massive stars, namely the hottest and largest of the main sequence, have about 50 times the mass of the sun, while the smallest known stellar masses, those of the feebly shining red dwarfs of the main sequence, contain about five per cent as much matter as the sun. The stars of small mass appear to be the most numerous in space (though not conspicuous in the sky because of their feeble radiation), while those of largest mass are very rare. It appears that, whatever the process of star formation, there is an upper limit to the amount of matter that can stick together in a single chunk. Amounts of matter smaller than some as-yet-undetermined limit are unable to generate their own energy, and hence, cannot shine as stars.

The desire of the moth for the star,
Of the night for the morrow,
The devotion to something afar
From the sphere of our sorrow.
—Shelly

satellite periods and the gravitational constant

By Edgar W. Woollard

assistant director,
nautical almanac office
u. s. naval observatory

EDITOR'S INTRODUCTION: Earth satellite problems, such as those encountered with Project Vanguard, require an exact knowledge of the relationship between the satellite periods of revolution around the earth, distance from the earth, size and shape of the earth, and distribution of the earth's mass. Of fundamental importance is the value of the Gaussian Constant of Gravitation. Will it have the same value as that used in solving planetary problems, or will it be different, and why? There is no disagreement among astronomers that one and only one constant, k^2 , exists. There is, however, a very real question concerning the auxiliary constant and units that should be employed with k^2 . One school of thought*, that of Herrick, Samuel, Baker and Hilton, favors different values of k^2 depending upon the case in question: whether planetary or earth-satellite. Another school, represented by Dr. Woollard and C. M. Clemence, Directors of the Nautical Almanac Office, favors use of just one constant in all calculations. For those readers who are curious as to how k^2 enters Kepler's Third, or Harmonic Law, a numerical example is appended at the end of this article. Dr. Woollard's views now follow.**

IN MY JUDGMENT, there is no method that could be relied upon to give better value of the periods of close earth satellites, or that would be more advantageous in any respect, than the conversion of the Gaussian constant to the most convenient units by means of conversion factors obtained from the standard system of astronomical constants used in the national ephemerides.

In undisturbed elliptic motion, the mean motion n of a mass m (from which the period $2\pi/n$ is immediately obtained), and the mean distance a from the primary mass M , are rigorously connected by the relation

$$n^2 a^3 = (\text{const. of grav.}) \times (M + m).$$

In terms of the astronomical system of units of length, mass and time, the numerical value of the constant of gravitation is k^2 , where k is the Gaussian constant which, as explained in the AMERICAN EPHEM-

*Herrick, Samuel, Baker and Hilton are co-authors of "Units and Constants for Geocentric Orbits" and members of the Department of Astronomy, University of California, and Systems Laboratories Corp., Los Angeles. They also serve as consultants for the International Geophysical Year Satellite Program, through the Smithsonian Astrophysical Observatory.

**From a letter dated 18 May 1956.

ERIS (page 611 of the 1956 volume) is fixed by definition at exactly 0.017 202 098 95.

To obtain the value of the constant of gravitation in any other system of units, the factors required are in some cases only definitions, such as the ratio of the day to the second, but in general they depend upon actual measurements; in particular, the value in cgs units can be obtained only by direct measurement. As illustrated by various examples, many different methods may be used, depending upon different quantities and different relations among them; and in the case of the quantities that are determined by measurement, it is necessary to decide which of the determinations on record in the literature to adopt. However, either in different methods or in any particular method, the values of the different quantities which may have to be used cannot always be assigned independently. Numerical values must be used which are consistent with all the theoretical relations that may exist among the quantities, and which are in strict accordance with the exact definitions of these quantities. If this is done, and if the number of significant figures required for computational consistency is retained in each arithmetical operation, irrespective of whether all of them are physically significant, the same results will be obtained by any method. In selecting numerical values to adopt for any particular set of quantities, there is no basis at present for not using the internationally accepted system of astronomical constants.

For example, in units of the kilometer, the hour, and the mass of the earth, the constant of gravitation may be obtained by converting either k^2 , or, less conveniently, the measured laboratory value G , to these units. The conversion of G requires the mass of the earth in grams, which may be derived from G by two or three different methods; but in any meth-

od, some of the same constants that must be used are likewise either required in converting k^2 or are related to constants involved in converting k^2 . With Heyl's value $G = 6.673 \times 10^{-8}$ cgs, and solar parallax 8".80, equatorial radius of the earth 6378388 meters, mass of sun/mass of earth 333 432, both methods when correctly applied give,

$$5.148\ 649\ 3 \times 10^{12}.$$

$$[\text{Km}^3 / \text{Hr}^2 \text{ earth masses}]$$

Nothing would be gained by basing the calculation on the motion of the moon. In the disturbed motion of any body, the value of a calculated from the observed mean motion is the semi-major axis of an elliptic reference orbit which necessarily is conventional and is in a mathematically arbitrary relation to the actual motion. The distance of the moon, given on page xvi of the AMERICAN EPHEMERIS, at which the parallax is 57'02".70, is not this elliptic mean distance, but is derived from the a calculated from the mean motion with the Gaussian constant; its relation to a , by means of which it is determined, depends upon the lunar perturbations.

EDITOR'S EXAMPLE: If the mass of the earth plus the mass of the satellite, $(M+m)$, is unity, then Kepler's Third Law becomes:

$$k^2 p^2 = (2\pi)^2 a^3$$

when, for the earth:

$$k^2 = 5.148\ 649\ 3 \times 10^{12}$$

p = sidereal period of revolution around earth (hrs)

a = distance from earth's center (km)
(equatorial diameter plus altitude)

If $a = 6778.386$ km (6378.388 km + 400 km altitude)

Then: $p = 1.545\ 336$ hrs.

Therefore, the satellite revolves around the earth in 1.545 hours with respect to the stars.



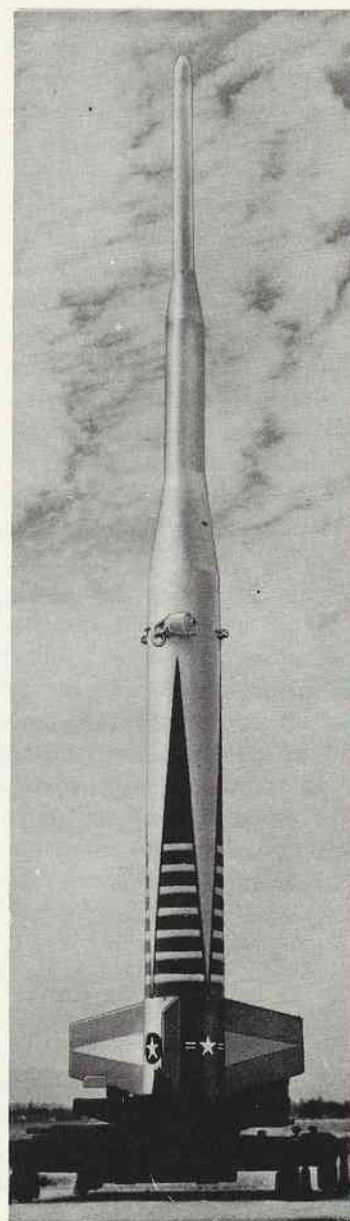
Alvis Howard, Jr.

MOON CAPABILITY ?

The largest solid propellant missile that has ever been proved out in flight test was recently unveiled by the Air Force's Major General B. A. Schriever at the annual meeting of the Institute of Aeronautical Sciences. The three-stage test vehicle is fired vertically into the atmosphere by a first or booster stage and, after it starts to descend, the other two stages are fired to accelerate the payload to super velocities.

The missile is designed to provide information which will help solve problems encountered in the re-entry (into the earth's atmosphere) phase of ballistic missile trajectories (flight paths). The first stage of the Lockheed X-17 (official name), was developed by Thiokol Corporation at Redstone Arsenal and is a modification of the Army's Sergeant rocket engine. The second stage consists of three Recruit rockets also developed at Redstone Arsenal by Thiokol. The third stage consists of a single Thiokol Recruit rocket engine.

In an exclusive interview with Space Reporter, Dr. H. W. Ritchey, Technical Director of Thiokol's Redstone Division, speculated that if an additional (fourth) stage is added to the X-17, it is quite possible that the missile could reach the moon.



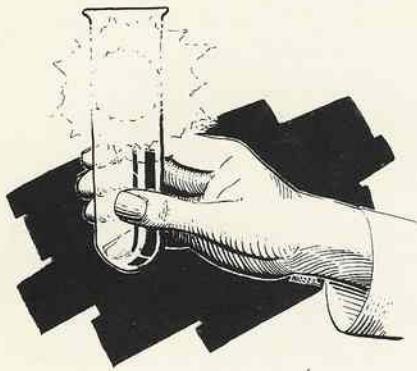
MARTIAN LIFE THEORY

Dr. I. M. Levitt of the Fels Planetarium, Philadelphia, states in his new book "A Space Traveler's Guide to Mars" that a tiny furry animal may greet the first visitors to Mars. The animals would not have lungs since Mars has so little atmosphere. He says that Martians might have a life chemistry or metabolism based on nitrogen rather than oxygen.

Dr. Levitt believes the animals would not drink water because water is so scarce, but they might get some water from the plants they eat. Also from the plants, they could get the tiny amounts of oxygen which they need. Their kidneys might not only cleanse their blood, but also generate some oxygen from their plant food. If there is plant life, the animals, by eating and digesting the plants, ultimately could set free some oxygen to re-enter the Martian atmosphere and become available again for new growth of plant life.

Many astronomers believe that plant life exists on Mars. They point to the fact that a blue area on the planet changes to green and back again to blue at regular intervals, indicating a periodic change with the seasons.





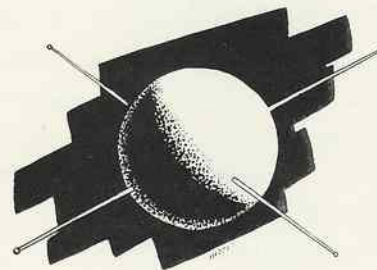
SYNTHETIC SUN

A "synthetic sun" for peaceful uses can be made in the laboratory, according to several British atomic scientists. They say it could be accomplished by utilizing the thermonuclear of H-bomb reaction and by holding down the energy of the action by magnetic forces.

The use of "high-temperature pulsed reaction" should prevent the synthetic sun from vaporizing everything with which it is in direct contact. The scientists suggested that the constant high temperature needed could be extracted from one-cubic-meter mass of deuterium-tritium gas.

FIRST SATELLITE WILL 'HEAR'

Researcher Robert C. Baumann of the Naval Research Laboratory, speaking before the American Rocket Society, said that the earth satellite to be launched during the International Geophysical Year will carry four small microphones which will be attached to the shell of the 20-inch sphere. The microphones will be linked with a "micro-meter counter" inside the shell. The microphones will tune in on tiny meteors as they whiz past the 21½ pound sphere. This will enable scientists to evaluate the number of these objects in space.



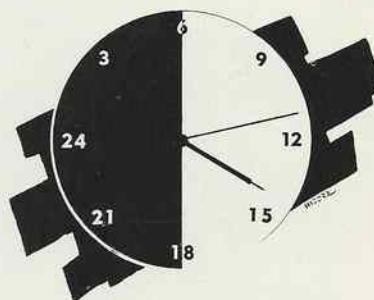
Mr. Baumann also stated that the satellite would require a 72-foot long rocket weighing 10 tons to launch it into its orbit. He said the earth satellite will be instrumental in unlocking some of the secrets of our planet and the space which surrounds us.

The earth, as it appears in photographs taken by a Navy Viking rocket at an altitude of 147 miles, seems uninhabited. Similar photographs of other planets, even the moon, might well give the same illusion.

Summing up the Vanguard project, Mr. Baumann stated: "The human race has just begun to scratch the surface of the unknown universe. Perhaps this small 20-inch diameter sphere, which we hope will become a satellite of the earth, with its electronics, batteries and measuring devices, will open the entirely unexplored reaches of space."

ARTIFICIAL DAY-NIGHT CYCLES

A regular pattern of sleep and rest for the crew of manned space ships must be established, according to Dr. Hubertus Strughold, noted expert on Space Medicine. Dr. Strughold, Director of the School of Aviation Medicine at Randolph Air Force Base in Texas, says that artificial day-night cycles similar to the pattern of earth would be a necessary discipline.

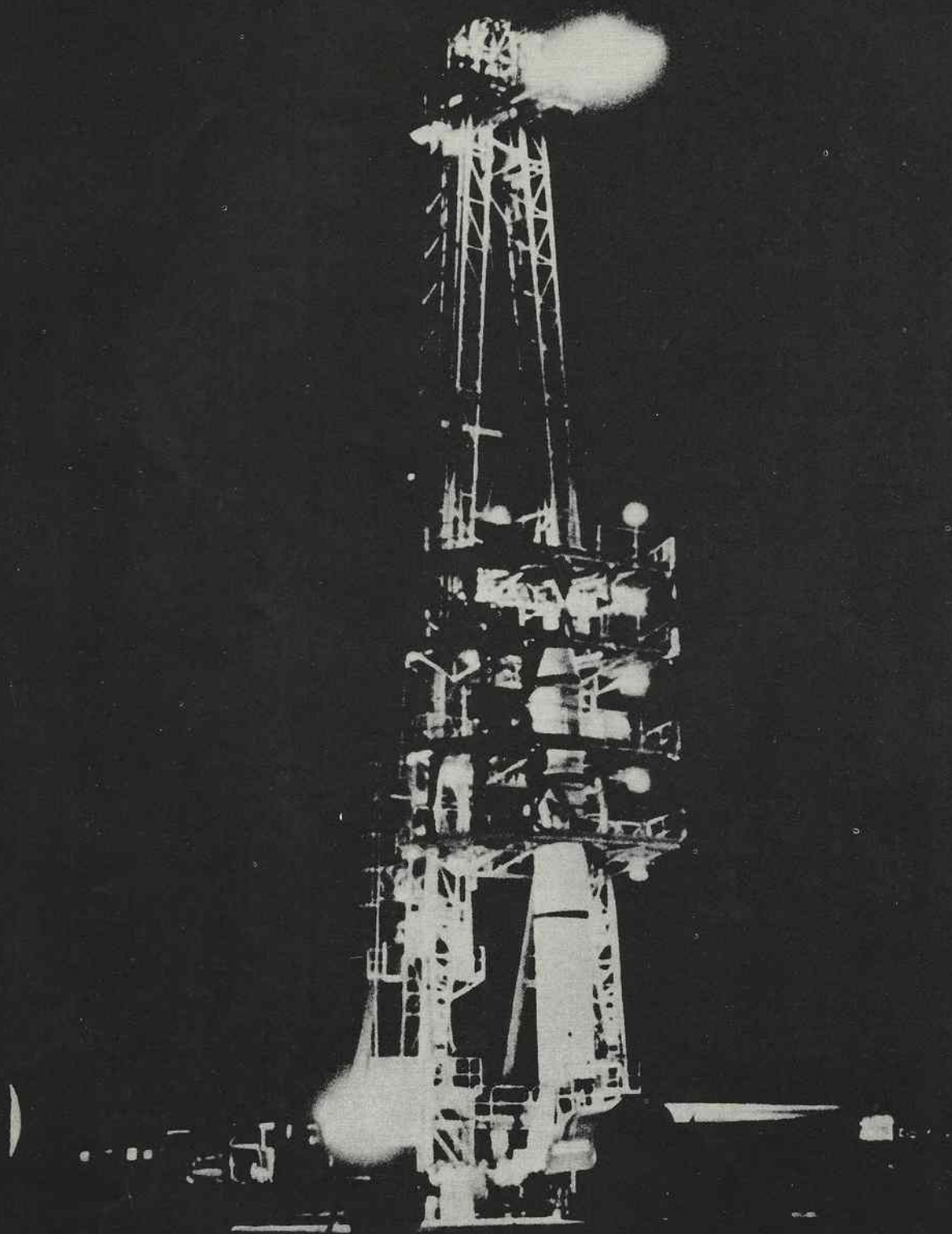


GREAT MINDS
DISCUSS IDEAS,

AVERAGE MINDS
DISCUSS EVENTS,

SMALL MINDS
DISCUSS PEOPLE.

—Anon



Final preparations are being made for early morning launching of the Army's Redstone Missile.

Photo courtesy of Army Ballistic Missile Agency

because it is there

By Wernher von Braun

Explorers and scientists have never been motivated by economic urgency but by a fundamental drive to conquer the unknown and to seek the truth. The benefits of their undertakings come only in the wake of their actions. An example of man's desire to overcome nature is the conquest of Mt. Everest by Sir Edmond P. Hillary and the Sherpa, Tensing Norkay. When asked why he was motivated to scale Everest, Sir Edmond electrified the world with the simplicity of his answer: "Because it is there."

Vasco da Gama eventually reached Calicut, thus being the first European to complete a sea voyage to India. Upon his return he had covered approximately 24,000 nautical miles, his voyage being one of the finest feats of seamanship known up to that time. It must be realized also that Christopher Columbus in his conceptions was but one among many, and that his greatness lay in his faith and persistence in his dream in the face of repeated rebuffs and disappointments.

Both of these men were motivated by a burning desire to discover the unknown. In the case of da Gama's voyage, it opened the way for the India trade which soon brought Portugal immense wealth. The Columbus voyage profoundly changed the course of world events, and with it American history begins. In both instances it can be readily seen that the benefits of their explorations came in the wake of their discoveries.

The same situation prevails with regard to research. People are gradually beginning to learn that research must be supported for its own sake. Knowledge is power, and there should be a concerted effort to inculcate in the minds of men the idea of "Ars Gratia Artis" with regard to research. Man's future well-being as well as his security will depend upon the growth of fundamental knowledge. Research is like saving: If postponed until needed, it is too late to start.

Man must have the intellectual freedom to think those dangerous thoughts which are the quintessence of science. Success in research is not measured by the amount of money expended. Real effectiveness comes from the brilliance of an imaginative and unfettered scientific mind. A hundred scientists, or even a thousand, cannot be equivalent to one first-rate man working in an environment where he has freedom to exercise his imagination.

There is nothing fictional about proposals of interplanetary travel, except that the engineering difficulties are staggering. No basic physical laws are violated. We have, or will acquire, the basic knowledge to solve all the physical problems of interplanetary flight. The matter of expenditures is petty and insignificant compared to what mankind stands to gain by conquering space.

The "Reaction" Department will be reserved in future issues of SJ for vox populi. Since this is the first issue, Dr. von Braun is pinch-hitting for the readers.

Lybrand

ABOUT THE AUTHOR

When we asked Yewell Lybrand to submit a short story for publication in the first issue of *SPACE JOURNAL*, he warned us that we were asking for trouble. His first short story was bought in 1954 for a Sunday newspaper's magazine supplement. The magazine discontinued its fiction feature before Lybrand's story was published. Last year *BLUEBOOK* magazine published one of his short stories, only to go out of business a few short months later. In June *COLLIER'S* bought one of his short stories, scheduled it for publication, and promptly bought another story from him. The rest is history. *COLLIER'S* suspended publication before Lybrand's short stories were published.

Lybrand is 27, married, and the father of two little girls. He is currently writing a novel, when not working at the Army Ballistic Missile Agency as a publications officer or fishing in the TVA lakes. *The Pioneer* is his first science-fiction story. We like to think that it is the first of many, in spite of his warning.

Early in April Miss Minnie sat on the morning side of her little house at the mountain's foot, her thin, blue hands limp across her lap. She reached down suddenly and picked up the newspaper lying at her feet, unfolded it, and read for the third time that morning:

"MOSCOW, April 3 (AP)—Informed sources reported in an official leak today that a Russian-manned space vehicle will leave tonight for the moon.

"Soviet Minister of Space Research Vladimir Loystok was quoted as saying: 'Tonight we shall do what the United States has failed to do. Our ship will reach its destination'."

Loystok's reference to the ill-fated U. S. Space Ship Lunar brought a red-faced "no comment" from the Pentagon. U. S. officials have refused to comment on the Lunar since its December launching, except to say that "audio contact with Lt. Arnold Lockridge, the Lunar's pilot, was terminated at sixteen hundred seconds after launching. Telemetry indicated that the pilot's physical condition was excellent at time of audio-cut-off, and continued excellent through telemetry cut-off. All instrumentation aboard the Lunar was in excellent working order."

The Department of Defense has refused to confirm or deny a report that the pilot was a victim of severe mental shock.

In Appleton, Wisconsin, the mother of the Lunar's pilot refused again to talk with reporters.

"She'd be all right if she knew for sure that Arnold was dead," a neighbor said. "But this Russian stuff has just got her stirred up again. She read in the newspapers that Arnold might just keep on going for a long, long time."

The morning sun climbed higher, and Miss Minnie folded her paper and dropped it beside her chair again. She sat quietly, waiting for Mr. Bevo to come to see her about her land on the mountain top again. Miss Minnie did not wait long.

She watched them as they parked their station wagon, and then picked their way from flat rock to flat rock up the hill until they had reached the broom-swept nakedness of her front yard.

Mr. Bevo, the oldest man, the one in front, tripped over the roots of the red oak tree at the yard's edge, the same roots that had tripped him on two earlier visits. Miss Minnie smiled. The two younger men, whom she had not seen before, rushed forward and helped Mr. Bevo



Luther drew a circle on the smooth ground. "This is us," he said.

RICE
10

to his feet, and the three continued walking across the yard until a corner of the house cut them from Miss Minnie's vision. She bumped her cane bottomed chair forward, grunted with the jar of the impact, then stood, brushed the skirts of her blue, everyday dress, and walked to the corner of the house.

The three men stopped when they saw her. Mr. Bevo stepped forward and removed his hat. He was a heavy man, perspiring from his climb up the hill, with dark hair combed thin across his balding head. He did not bother to wish her good-morning, but spoke quickly, curtly.

"We've come about the land again."

Miss Minnie nodded. "I read about them Russians. I figgered you'd be up here in a hurry today."

Mr. Bevo smiled and raised his hat as if to place it on his head. "Then you'll sell."

Miss Minnie did not answer. She looked past Mr. Bevo at the two younger men. They were both in their twenties, one of them dressed in a dark gray suit, the other in an Army uniform with the shoulder patch of the military base in the valley.

"Which one of you is Mr. Willis?" she asked.

The uniformed young man stepped forward and laughed softly. His hair was closely cut, giving his broad, tanned face a boyish frame.

"That's me, mam. Luther Willis." He pointed to the young man in the gray suit standing beside him. "And this is Harold Mabry."

"You come from around here somewhere?"

"No, mam," Luther answered. "I'm from North Carolina." He grinned. "But it's the same mountain."

Miss Minnie grunted. "My daddy's folks come here from North Carolina. Don't know they ever mentioned any Willisses, though."

"No, mam," Luther said.

"You got nice teeth."

Luther blushed and looked at his feet.

"Thank you, mam."

Harold laughed. "It's his bicuspid that always gets them."

Miss Minnie turned to face Harold. "You and Mr. Bevo just set on the porch. I want to talk to Mr. Willis."

When the two men had settled themselves into rocking chairs on the porch Miss Minnie again faced Luther.

"You ain't scared of this crazy mess, Luther?"

Luther laughed. "Just scared enough to be careful."

"And that other feller, the one I read about who went out there and just kept right on goin' and never did come back and never will come back, that feller, he was careful too. Ain't that so?"

Luther's grin left his face. "Yessum. I guess he was right careful."

Miss Minnie grunted. "Bein' careful didn't do him much good, did it?"

Luther shook his head. "No, mam. But this time it will be different. This time we've learned a few things. That's why we are going to . . . why we want to build a new launching platform. The new ship will be bigger, and better. But we've got to hurry."

"I asked 'em before and they answered me somethin' I couldn't even get half sense out of. How come you have to build this thing up here? There are plenty of mountains around here. And the government already owns most of 'em."

"No roads," Luther said. "This one has a road. No electric power. This one has power."

Miss Minnie pointed down toward the valley. "You own half a county right down there. Use it."

"It's too crowded, mam. We need this up here."

"S'pose I don't sell it to you."

Luther frowned. "Miss Minnie I wouldn't like to see you do that. They'd condemn your land and get it anyhow, and that

would mean a lot of court trouble. And a lot of time. And we don't have much time."

Miss Minnie grunted.

"Miss Minnie, you got any reasons for *not* wanting us to build a launching site up here?"

She grunted again. "I don't reckon I'm obliged to give you a reason for not sellin' what's been mine for forty years."

He blushed. "No, mam. I just thought maybe there was some religious..."

Miss Minnie laughed, a harsh laugh that caused Mr. Bevo to cough. "You just like them. You think ever'body born on the side of a hill thinks anything new is sinful." Miss Minnie stepped closer until she could hear Luther breathing. "I reckon it this way: the Lord give you or them or somebody enough sense to wonder about what was out there, so I reckon that gives you the right to try and find out. Only not me. I don't care nothin' about what's out there. I don't even care nothin' about what's down there in the valley, except my married sister down in town."

"But that..."

"Don't tell me nothin'," Miss Minnie said. "I don't want to know nothin. I got no quarrel with the way folks live nowadays. That's fine and dandy. But it don't put no grits on my table."

"They'll pay you. Forty thousand dollars is a lot of money."

"Money!" Miss Minnie's voice rose and up on the porch Mr. Bevo stood quickly. "You git sixty-nine years old and lose your teeth and your neighbors that you growed up with and lose even the way you're used to doin' things and see how much you care about anything but the land you was brought up on."

"Miss Minnie, have you done any thinking about what's going to happen to your land when you aren't here to take care of it?"

Miss Minnie bit her lip. "Mister Luther Willis," she said evenly, "I reckon you're too young to a-heard a woman cuss, but

what happens after I'm dead and gone is just another one of them things I don't give a damn about."

Luther looked down at his feet. "Yes, mam," he said. He looked up. "Miss Minnie, I'm sorry we're causing you so much worry. Maybe I shouldn't even have come up here. This isn't my job, but they said you had read about me in the papers, about me and the Project. They thought I might be able to influence you."

Miss Minnie grunted.

"We need this mountain pretty bad now, mam. We can build somewhere else. But this is closer. It will cost less money and take less time. If we wait much longer they'll have Mars too."

Miss Minnie grunted. "You and all the rest of the world talk about it like maybe you owned every square foot of it. Like maybe you and Russia and God was goin' to sit down and draw straws for the moon."

Luther grinned. "No, mam. We've lost the moon."

"You think they'll get there?"

Luther nodded. "I know they will. That's why we've got to hurry." Luther looked briefly away from her at the mountain which rose behind the house. "And besides all that, mam, I want to do this more than anything I've ever wanted. Next year I'll be too old. They'll pick out somebody else, then. Maybe Harold, the young boy up there on the porch. He's next in line."

"How do you know you'll get there?"

Luther looked around him, squatted suddenly, picked up a small stick, and drew a circle on the smooth ground. "This is us," he said. He looked up at her and grinned. "You and me, Miss Minnie. And this," (he began drawing again) "this is the way we're going around the sun. And this... this here is the way this other planet is going. It's closest to us right here." He looked up at her. "And right here's where we've got to jump off, mam."

"How you know that?" Miss Minnie asked.

Luther pointed toward the porch. "Mr. Bevo. I guess he knows more about this stuff than anybody."

Miss Minnie stared at Mr. Bevo. "I don't mean nothin' personal by this, but he don't look like he knows much more'n anybody else."

Mr. Bevo coughed again. "Well, Willis?" He called from the porch.

Luther stood and dropped his stick. "I guess we can go, Mr. Bevo."

Mr. Bevo walked down the steps, the young man close on his heels. Mr. Bevo began smiling when he looked at Miss Minnie. He held his hat lightly in his hands and walked toward her. "Well, mam. What have we decided this time?"

"We've decided," Miss Minnie said, "that somebody down there at the Army base is sure spendin' a lot of money on gasoline, havin' a bunch of new folks drive up here ever' two or three days."

Mr. Bevo put on his hat. "We thank you for your time. Goodday." He walked tight-lipped between Luther and Miss Minnie, with Harold close behind him.

"Goodbye, Miss Minnie," Luther said. He held out his hand.

Miss Minnie smiled. "You wait just a minute." She hurried up the steps and into the house. When she returned Luther was still waiting, and below them, at the foot of the hill, Mr. Bevo was tooting the horn of the station wagon. "You take this back with you," Miss Minnie said. She handed him a small jar. "It's crabapple jelly and it's a little dark, but it's good."

"Thank you, mam." He grinned at her. "And I sure do wish you'd change your mind."

"You go on," she answered. "And you tell that pro-cure-ment man down there to quit writin' me so dadblamed many letters. I'll sue him for cloggin' up my mail if he don't."

"Yes, mam."

Luther turned and walked across the

yard. He reached the first flat stone and began stepping down the face of the hill.

"And Luther," she called after him, "you come back. You come back to see me. You hear?"

He waved to her, but did not answer.

His picture was in the valley paper that night, Luther Willis standing beside the ship. Miss Minnie read the paper at supper, then folded the page with Luther's picture and propped it against the bowl from which she'd eaten her corn bread and buttermilk.

She stared at the picture for a few minutes, then arose, moved the paper aside, and began washing her dishes. When she had finished this Miss Minnie picked up the paper to place it atop the neat stack of back issues which she kept on the top of her kitchen cabinet. She looked at the picture again and grunted. "I bet he didn't even hear me," she said aloud.

When Luther returned to her house the following morning Miss Minnie was sitting on the top step of her front porch waiting for him.

She shooed him around to the warm side of the house. Luther removed the galvanized tubs and they sat on the white wash bench and drank thick, black coffee.

"Boy," she began, "I was layin' there lookin' out my window last night and I got to thinkin', and I prayed a prayer for you."

"Thank you, mam. I figure I might need more than a few."

"The way I reckon it you'll need more than a few."

"This coffee's got chicory in it."

Miss Minnie nodded. "Talk to me. Tell me somethin' I want to know and don't start preachin' to me about bein' a hypocrite."

"Yessum?"

"What's it like out there, Luther?"

He set his coffee cup down on the edge of the bench and leaned forward, resting

his arms on his knees and interlacing his fingers.

"It's black, Miss Minnie. And cold. And it's a long way there and back." They sat in silence for a moment.

"It's not easy for somebody like me to think about things like this, boy."

"No, mam."

"I mean," she began, and paused, and in a lower voice continued, "I mean, when you ain't even rode in an airplane it's a little hard to think about anybody ridin' in something even worse. And farther. And then I get to thinkin' about my kind

of folks. This ain't somethin' that my kind of folks would set out to do, Luther."

"I'm you're kind," he answered.

She nodded. "That's what worries me."

"And something else," Luther said. "I saw a copy of the abstract which your granddaddy recorded on this land. It was bought from Indians."

Miss Minnie grunted. "Bought is one way to put it, I reckon."

"And he drove a ramshackled wagon behind a yoke of oxen all the way from North Carolina, didn't he?"

Miss Minnie grunted. "And walked his-

"I came to see Luther," she said, "the boy that's goin' to ride in that thing."



self ever' step of the way and stopped once to help his wife bear a young'un."

Miss Minnie looked quickly at Luther. "It ain't the same. And don't say it is."

"No, mam." Luther said. "It's sure not the same. And the big difference isn't the time. And it isn't the difference between what he was walking beside and what I'll be moving in. There's something bigger, like, how'd he ever get the guts to try it in the first place?"

Miss Minnie grinned, then laughed. "You didn't know my granddaddy. What drove him here wasn't guts. He was starvin' to death where he was."

"Do you know what I really meant?" Luther asked.

She nodded. "I know. You meant somebody had faith in my granddaddy and if you'll look me in the eye and tell me you know you're going to be able to go out there and come back in one piece, I'll not only sell you the mountain, I'll go with you."

Luther shook his head. "That's just what I don't know. Nobody knows, really. We work it out on paper. We build the . . ."

"The covered wagon," she interrupted.

Luther nodded. "The covered wagon. And then we try. But what counts most is that we believe we can do it. We've kept on believing we can do it, even when nobody else did."

"And that young boy, Arnold. Did he believe he could do it, Luther?"

Luther stood suddenly and picked up a small sand stone. He threw it high above the red oak and watched it arch into the hollow below the house. "No, mam," he said quietly, "I reckon Arnold didn't believe in anything much. The last thing he said was 'I'll show 'em, Luther. I'll show 'em'."

Luther returned to the wash bench and the two of them sat quietly, waiting as time softened the silence between them.

Miss Minnie grunted. "I'll go down to the valley and stay with my sister until

this thing is over with. Tell 'em to build their laun . . . laun . . ."

Luther grinned. "Launching site."

Miss Minnie nodded. "Tell 'em to build the damn thing."

.

They had not touched the house, and as she climbed up the hill on the flat stones she told herself that she would move back into it, regardless of the noise. The tower rose tall and gray from the mountain behind the house, smaller than it had appeared to her in the photographs which the valley newspapers had published.

She did not pause at the house, but walked quickly around it and began her slow climb up the mountain path to the launching tower. A man in a uniform stopped her before she reached it.

"I came to see Luther," she said. "That boy that's goin' to ride in that thing."

He was being strapped into the passenger capsule when she found him.

"You don't have much room in there," she said.

Luther laughed. "That's all right. I don't plan to do much walking around."

"I brought you somethin'," she said. "And I reckon I better give it to you. They said I could only stay two minutes."

She handed him a small jar. "It's the same batch, a little dark," she said. "Hope there's room for it."

"I'll make room," Luther said, and nodded.

"And Luther," she said, before the uniformed men began urging her away from the tower, "Luther, explain it to me agin."

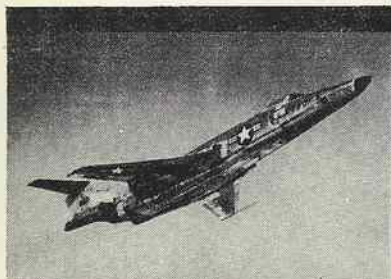
Luther grinned and drew an imaginary circle with his finger. "This is us," he called to her, "And this is where we jump off."

"You and me, Luther," she said quietly, and walked away toward her little house at the foot of the mountain.

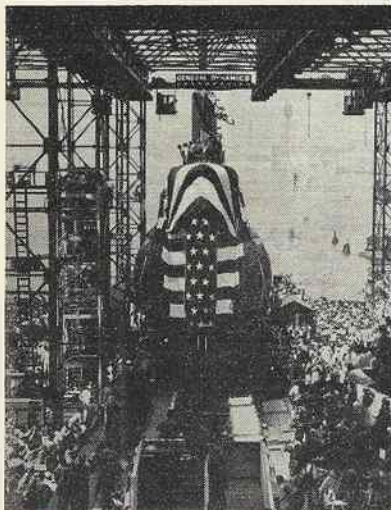
FICo COMPUTER AND CONTROL SYSTEMS

- For Weapons Control
- For Processing of Data
- For Special Purpose Computer and Control Applications

FICo engineers and produces the guidance for the Redstone Missile.
U.S. Army Photo

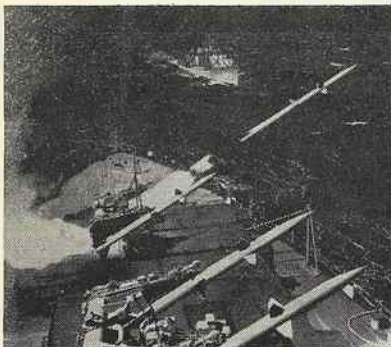


FICo navigational equipment goes into a wide range of aircraft.
U.S. Air Force Photo



FICo controls are used in the atomic submarine program. FICo is also working toward development of the closed-cycle gas-cooled reactor.

U.S. Navy Photo



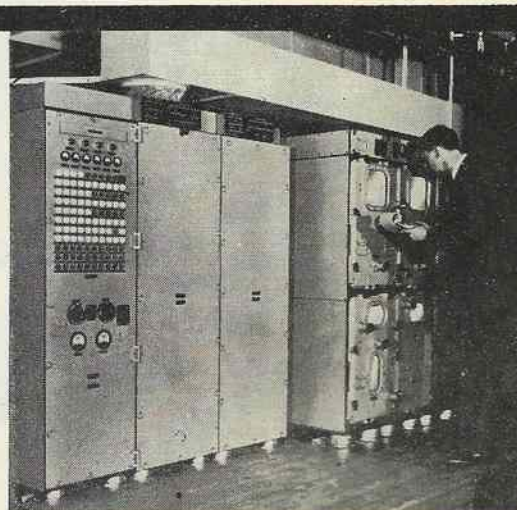
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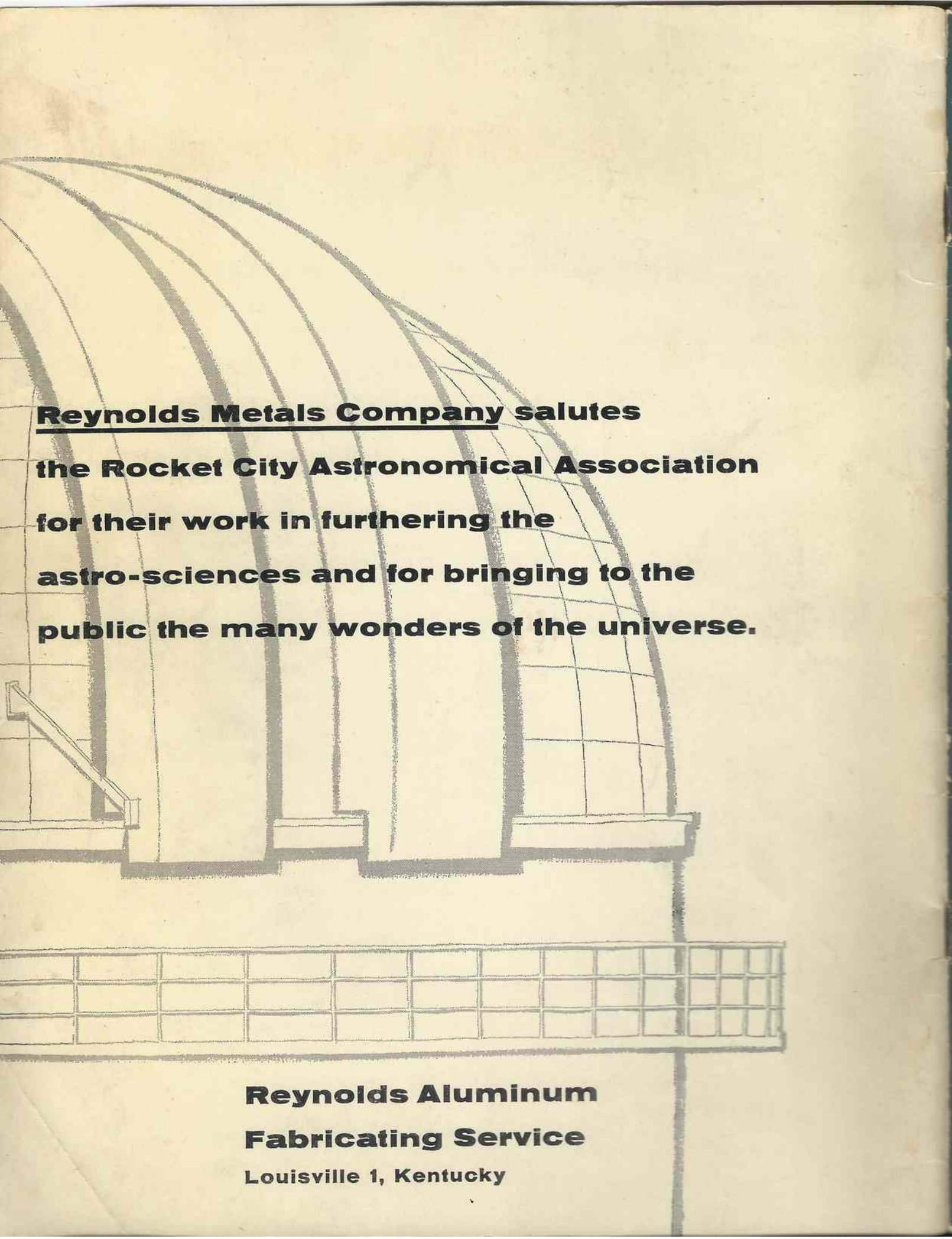
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