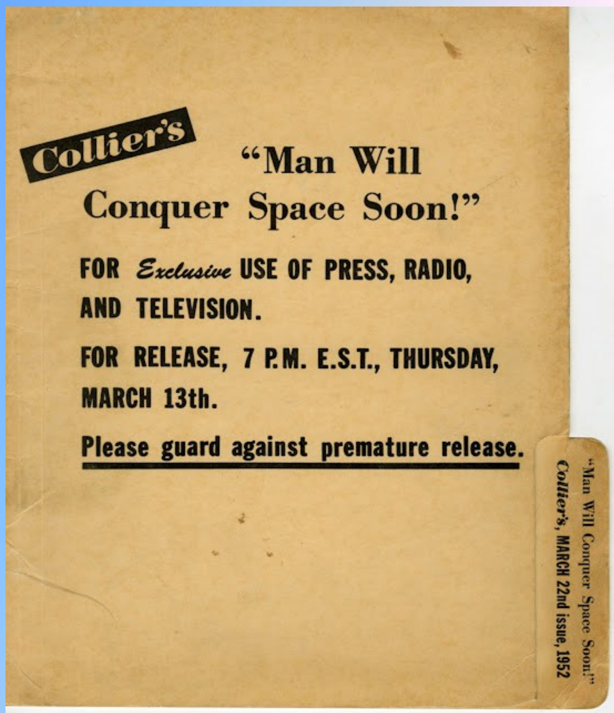
Collier's

March 22, 1952 • Fifteen Cents

Man Will Conquer Space Soon

TOP SCIENTISTS TELL HOW IN 15 STARTLING PAGES

Below: Part of a 1952 press release for the "Man Will Conquer Space Soon!," articles in the March 22, 1952 issue of Collier's. This is from John Sisson's Dreams of Space blog.



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March 22, 1952

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Editorial and Executive Offices, 640 Fifth Avenue, New York 19, N. Y.

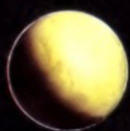
COLLIER'S THE NATIONAL WEEKLY Vol. 129, No. 12. **PUBLISHED WEEKLY** by The Crowell-Collier Publishing Company, Springfield, Ohio, U.S.A., Publishers of Collier's, Woman's Home Companion, The American Magazine. Executive and Editorial Offices, 640 Fifth Ave., New York 19, N. Y. Albert E. Winger, Chairman of the Board; Clarence E. Stouch, President; E. A. Schirmer, Executive Vice-President; T. L. Brantly, Peter J. Dennerlein, Edward Anthony, Robert T. Messler, E. P. Seymour, John W. McPherrin, Vice-Presidents; Denis O'Sullivan, Secretary; C. F. Norsworthy, Treasurer.

SUBSCRIPTION PRICES: United States and Possessions, and Philippine Islands, 1 year $5.00; 2 years $8.00; 2½ years (130 issues) $9.00; 3 years $10.00. Canada, 1 year $5.50. Pan-American countries in the Postal Union, 1 year $6.00. All other foreign countries, 1 year $9.00. Payments from foreign countries, except Canada, must be in United States funds, and addressed to The Crowell-Collier Publishing Co., Springfield, Ohio.

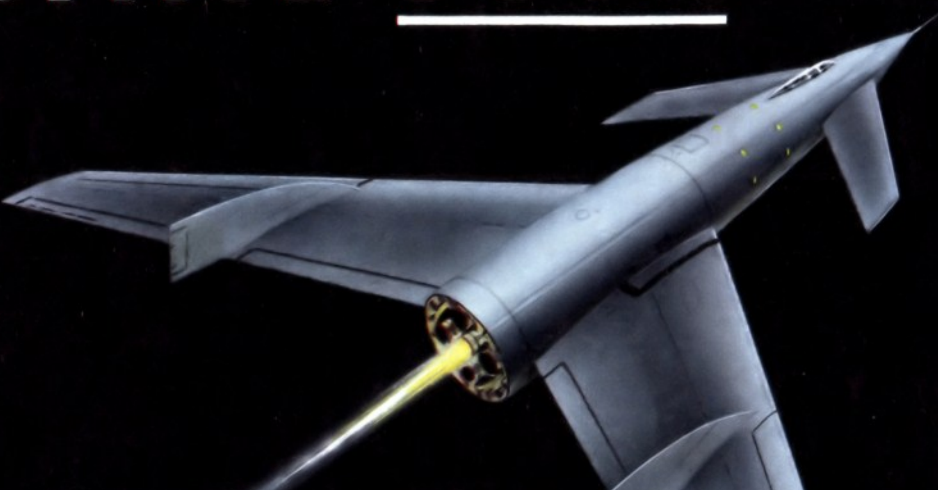
ENTERED as second-class matter at the Post Office, Springfield, Ohio, under Act of March 3, 1879. Authorized as second-class mail, Post Office Department, Ottawa, Canada.

MANUSCRIPTS or art submitted to Collier's, The National Weekly, should be accompanied by addressed envelopes and return postage. The Publisher assumes no responsibility for return of unsolicited manuscripts or art.

CHANGES OF ADDRESS should reach us five weeks in advance of the next issue date. Give both the old and new addresses.



MAN WILL CONQUER SPACE SOON



Some of the scientists and illustrators who took part in Collier's symposium (left to right): Rolf Klep, Willy Ley, Dr. Heinz Haber, Dr. Wernher von Braun, Dr. Fred L. Whipple, and Chesley Bonestell

What Are We Waiting For?

ON THE following pages Collier's presents what may be one of the most important scientific symposiums ever published by a national magazine. It is the story of the inevitability of man's conquest of space.

What you will read here is not science fiction. It is serious fact. Moreover, it is an urgent warning that the U.S. must immediately embark on a long-range development program to secure for the West "space superiority." If we do not, somebody else will. That somebody else very probably would be the Soviet Union.

The scientists of the Soviet Union, like those of the U.S., have reached the conclusion that it is now possible to establish an artificial satellite or "space station" in which man can live and work far beyond the earth's atmosphere. In the past it has been correctly said that the first nation to do this will control the earth. And it is too much to assume that Moscow's military planners have overlooked the military potentialities of such an instrument.

A ruthless foe established on a space station could actually subjugate the peoples of the world. Sweeping around the earth in a fixed orbit, like a second moon, this man-made island in the heavens could be used as a platform from which to launch guided missiles. Armed with atomic war heads, radar-controlled projectiles could be aimed at any target on the earth's surface with devastating accuracy.

Furthermore, because of their enormous speeds and relatively small size, it would be almost impossible to intercept them. In other words: whoever is the first to build a station in space can prevent any other nation from doing likewise.

We know that the Soviet Union, like the U.S., has an extensive guided missile and rocket program under way. Recently, however, the Soviets intimated that they were investigating the development of huge rockets capable of leaving the earth's atmosphere. One of their top scientists, Dr. M. K. Tikhonravov, a member of the Red Army's Military Academy of Artillery, let it be known that on the basis of Soviet scientific development such rocket ships could be built and, also, that the creation of a space station was not only feasible but definitely probable. Soviet engineers could even now, he declared, calculate precisely the characteristics of such space vehicles; and he added that Soviet developments in this field equaled, if not exceeded, those of the Western World.

We have already learned, to our sorrow, that Soviet scientists and engineers should never be underestimated. They produced the atomic bomb years earlier than was anticipated. Our air superiority over the Korean battlefields is being challenged by their excellent MIG-15 jet fighters which, at certain altitudes, have proved much faster than ours. And while it is not believed that the Soviet Union has actually begun work on a major project to capture space superiority, U.S. scientists point out that the basic knowledge for such a program has been available for the last 20 years.

What is the U.S. doing, if anything, in this field? In December, 1948, the late James Forrestal, then Secretary of Defense, spoke of the existence of an "earth satellite vehicle program." But in the opinion of competent military observers this was little more than a preliminary study. And so far as is known today, little further progress has been made. Collier's feels justified in asking: What are we waiting for?

We have the scientists and the engineers. We enjoy industrial superiority. We have the inventive genius. Why, therefore, have we not embarked on a major space program equivalent to that which was undertaken in developing the atomic bomb? The issue is virtually the same.

The atomic bomb has enabled the U.S. to buy time since the end of World War II. Speaking in Boston in 1949, Winston Churchill put it this way: "Europe would have been communized and London under bombardment some time ago but for the deterrent of the atomic bomb in the hands of the United States." The same could be said for a space station. In the hands of the West a space station, permanently established beyond the atmosphere, would be the greatest hope for peace the world has ever known. No nation could undertake preparations for war without the certain knowledge that it was being observed by the ever-watching eyes aboard the "sentinel in space." It would be the end of Iron Curtains wherever they might be.

Furthermore, the establishment of a space station would mean the dawning of a new era for mankind. For the first time, full exploration of the heavens would be possible, and the great secrets of the universe would be revealed.

When the atomic bomb program—the Manhattan Project—was initiated, nobody really knew whether such a weapon could actually be made. The famous Smyth Report on atomic energy tells us that among the scientists there were many who had grave and fundamental doubts of the success of the undertaking. It was a two-billion-dollar technical gamble.

Such would not be the case with a space program. The claim that huge rocket ships can be built and a space station created still stands unchallenged by any serious scientist. Our engineers can spell out right now (as you will see) the technical specifications for the rocket ship and space station in cut-and-dried figures. And they can detail the design features. All they need is time (about 10 years), money and authority.

Even the cost has been estimated: $4,000,000,000. And when one considers that we have spent nearly $54,000,000,000 on rearmament since the Korean war began, the expenditure of $4,000,000,000 to produce an instrument which would guarantee the peace of the world seems negligible.

Collier's became interested in this whole program last October when members of our editorial staff attended the First Annual Symposium on Space Travel, held at New York's Hayden Planetarium. On the basis of their findings, Collier's invited the top scientists in the field of space research to New York for a series of discussions. The magazine symposium on these pages was born of these round-table sessions.

The scientists who have worked with us over the last five months on this project and whose views are presented on the succeeding pages are:

- **Dr. Wernher von Braun,** Technical Director of the Army Ordnance Guided Missiles Development Group. At forty, he is considered the foremost rocket engineer in the world today. He was brought to this country from Germany by the U.S. government in 1945.
- **Dr. Fred L. Whipple,** Chairman, Department of Astronomy, Harvard University. One of the nation's outstanding astronomers, he has spent most of his forty-five years studying the behavior of meteorites.
- **Dr. Joseph Kaplan,** Professor of Physics at UCLA. One of the nation's top physicists and a world-renowned authority on the upper atmosphere, the forty-nine-year-old scientist was decorated in 1947 for work in connection with B-29 bomber operations.
- **Dr. Heinz Haber,** of the U.S. Air Force's Department of Space Medicine. Author of more than 25 scientific papers since our government brought him to this country from Germany in 1947, Dr. Haber, thirty-eight, is one of a small group of scientists working on the medical aspects of man in space.
- **Willy Ley,** who acted as adviser to Collier's in the preparation of this project. Mr. Ley, forty-six, is perhaps the best-known magazine science writer in the U.S. today. Originally a paleontologist, he was one of the founders of the German Rocket Society in 1927 and was Dr. Wernher von Braun's first tutor in rocket research.

Others who made outstanding contributions to this issue include:

- **Oscar Schachter,** Deputy Director of the UN Legal Department. A recognized authority on international law, this thirty-six-year-old lawyer has frequently given legal advice on matters pertaining to international scientific questions, which lately have included the problems of space travel.
- **Chesley Bonestell,** whose art has appeared in the pages of Collier's many times before. Famous for his astronomical paintings, Mr. Bonestell began his career as an architect, but has spent most of his life painting for magazines and lately for Hollywood.
- Artists **Fred Freeman** and **Rolf Klep.** Both spent many months working in conjunction with the scientists.

For Collier's, associate editor Cornelius Ryan supervised assembly of the material for the symposium. The views expressed by the contributors are necessarily their own and in no way reflect those of the organizations to which they are attached.

Collier's believes that the time has come for Washington to give priority of attention to the matter of space superiority. The rearmament gap between the East and West has been steadily closing. And nothing, in our opinion, should be left undone that might guarantee the peace of the world. It's as simple as that.

THE EDITORS

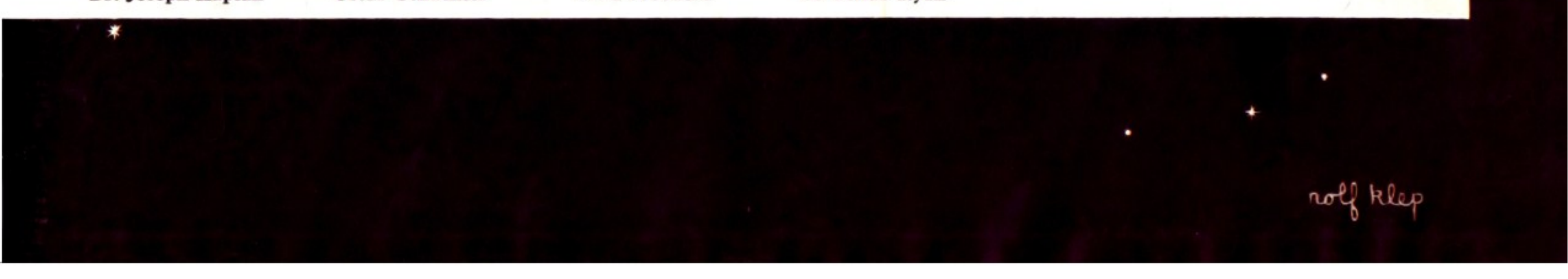
Dr. Joseph Kaplan

Oscar Schachter

Fred Freeman

Cornelius Ryan

DRAWINGS BY ROLF KLEP



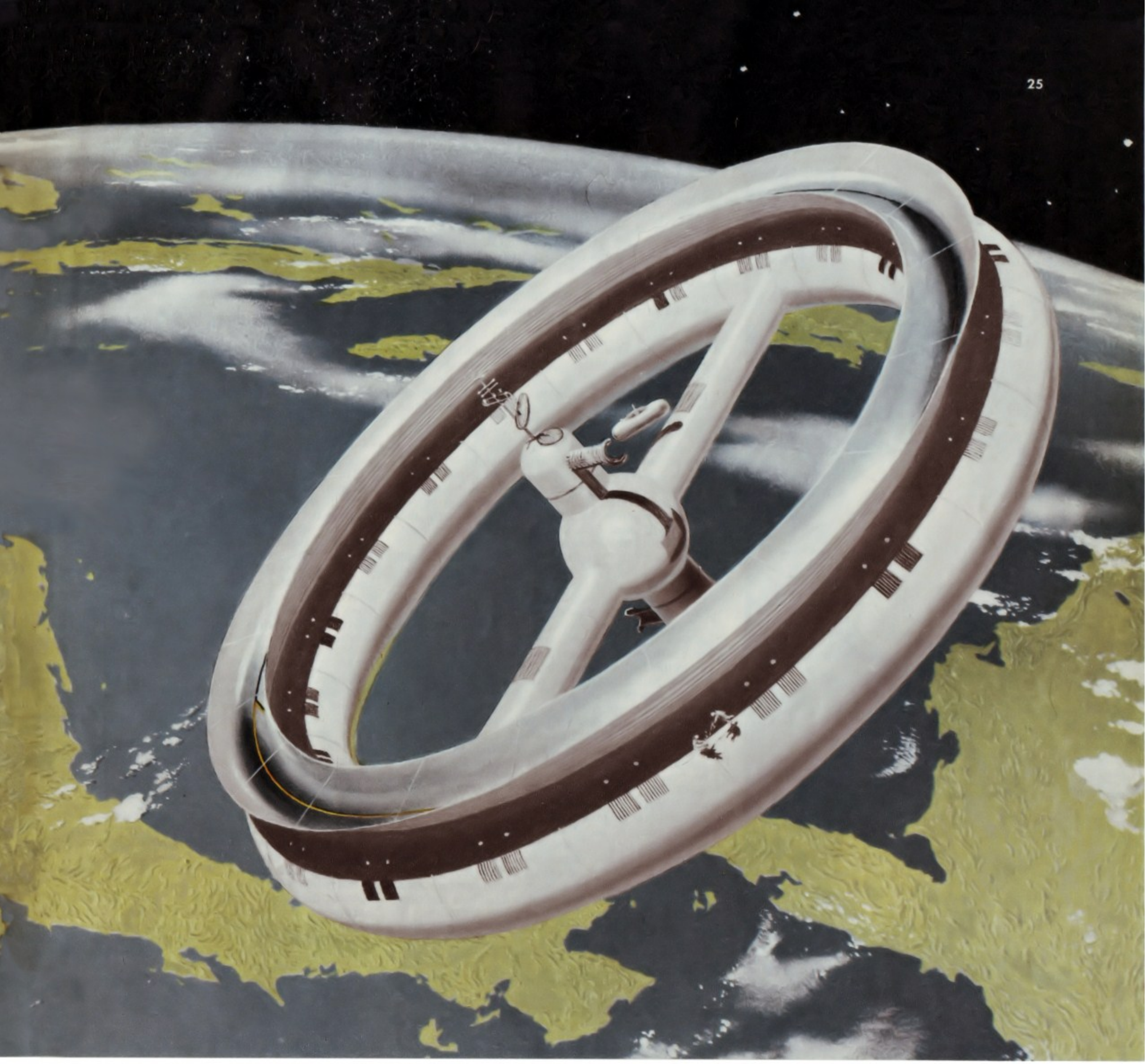
Men and materials arrive in the winged rocket and take "space taxis" to wheel-shaped space station at right. Men wear pressurized suits

CROSSING THE LAST FRONTIER

By DR. WERNHER von BRAUN

Technical Director, Army Ordnance Guided Missiles Development Group, Huntsville, Alabama

Scientists and engineers now know how to build a station in space that would circle the earth 1,075 miles up. The job would take 10 years, and cost twice as much as the atom bomb. If we do it, we can not only preserve the peace but we can take a long step toward uniting mankind



Three "space taxis" can be seen—one leaving rocket, another reaching satellite, a third near the already-built astronomical observatory

WITHIN the next 10 or 15 years, the earth will have a new companion in the skies, a man-made satellite that could be either the greatest force for peace ever devised, or one of the most terrible weapons of war—depending on who makes and controls it. Inhabited by humans, and visible from the ground as a fast-moving star, it will sweep around the earth at an incredible rate of speed in that dark void beyond the atmosphere which is known as "space."

In the opinion of many top experts, this artificial moon—which will be carried into space, piece by piece, by rocket ships—will travel along a celestial route 1,075 miles above the earth, completing a trip around the globe every two hours. Nature will provide the motive power; a neat balance between its speed and the earth's gravitational pull will keep it on course (just as the moon is fixed in its orbit by the same two factors). The speed at which the 250-foot-wide, "wheel"-shaped satellite will move will be an almost unbelievable 4.4 miles per second, or 15,840 miles per hour—20 times the speed of sound. However, this terrific velocity will not be apparent to its occupants. To them, the space station will appear to be a perfectly steady platform.

From this platform, a trip to the moon itself will be just a step, as scientists reckon distance in space.

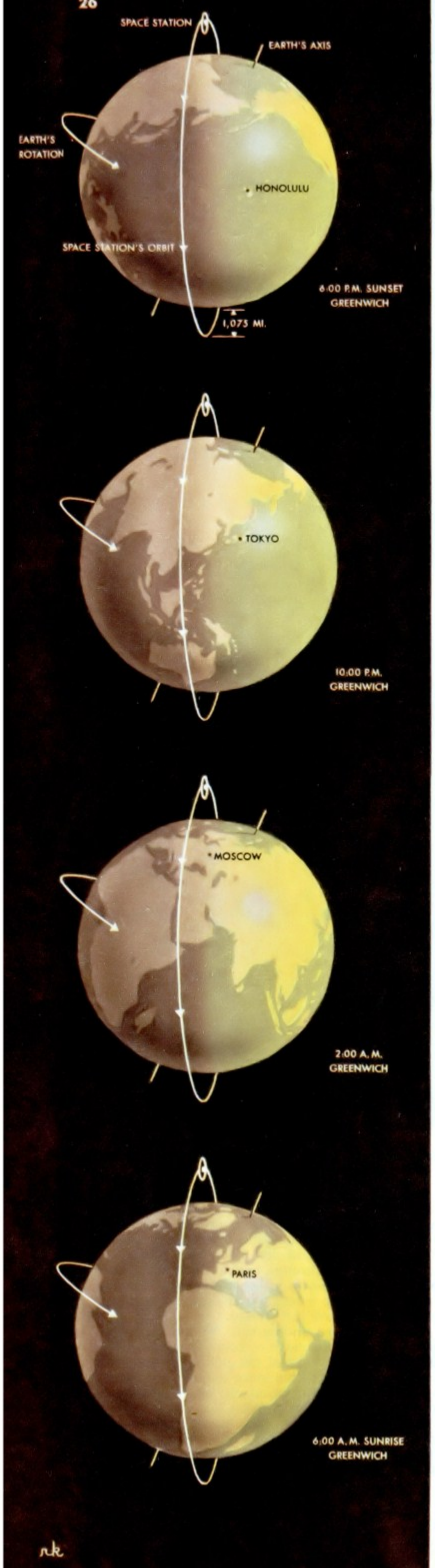
The choice of the so-called "two-hour" orbit—in preference to a faster one, closer to the earth, or a slower one like the 29-day orbit of the moon—has one major advantage: although far enough up to avoid the hazards of the earth's atmosphere, it is close enough to afford a superb observation post.

Technicians in this space station—using specially designed, powerful telescopes attached to large optical screens, radarscopes and cameras—will keep under constant inspection every ocean, continent, country and city. Even small towns will be clearly visible through optical instruments that will give the watchers in space the same vantage point enjoyed by a man in an observation plane only 5,000 feet off the ground.

Nothing will go unobserved. Within each two-hour period, as the earth revolves inside the satellite's orbit, one twelfth of the globe's territory will pass into the view of the space station's occupants; within each 24-hour period, the entire surface of the earth will have been visible.

Over North America, for example, the space station might pass over the East Coast at, say 10:00 A.M., and, after having completed a full revolution around the earth, would—because the

PAINTING BY CHESLEY BONESTELL



earth itself has turned meanwhile—pass over the West Coast two hours later. In the course of that one revolution it would have been north as far as Nome, Alaska, and south almost to Little America on the Antarctic Continent. At 10:00 A.M. the next day, it would appear once again over the East Coast.

Despite the vast territory thus covered, selected spots on the earth could receive pinpoint examination. For example, troop maneuvers, planes being readied on the flight deck of an aircraft carrier, or bombers forming into groups over an airfield will be clearly discernible. Because of the telescopic eyes and cameras of the space station, it will be almost impossible for any nation to hide warlike preparations for any length of time.

* * *

These things we know from high-altitude photographs and astronomical studies: to the naked eye, the earth, more than 1,000 miles below, will appear as a gigantic, glowing globe. It will be an awe-inspiring sight. On the earth's "day" side, the space station's crew will see glaring white patches of overcast reflecting the light of the sun. The continents will stand out in shades of gray and brown bordering the brilliant blue of the seas. North America will look like a great patchwork of brown, gray and green reaching all the way to the snow-covered Rockies. And one polar cap—whichever happens to be enjoying summer at the time—will show as a blinding white, too brilliant to look at with the naked eye.

On the earth's "night" side, the world's cities will be clearly visible as twinkling points of light. Surrounded by the hazy aura of its atmosphere—that great ocean of air in which we live—the earth will be framed by the absolute black of space.

Development of the space station is as inevitable as the rising of the sun; man has already poked his nose into space and he is not likely to pull it back.

On the 14th of September, 1944, a German V-2 rocket, launched from a small island in the Baltic, soared to a peak altitude of 109 miles. Two years later, on December 17, 1946, another V-2, fired at the Army Ordnance's White Sands Proving Ground, New Mexico, reached a height of 114 miles—more than five times the highest altitude ever attained by a meteorological sounding balloon. And on the 24th of February, 1949, a "two-stage rocket" (a small rocket named the "WAC Corporal," fired from the nose of a V-2 acting as carrier or "first stage") soared up to a height of 250 miles—roughly the distance between New York and Washington, but straight up!

These projectiles utilize the same principle of propulsion as the jet airplane. It is based on Isaac Newton's third law of motion, which can be stated this way: for every action there must be a reaction of equal force, but in the opposite direction. A good example is the firing of a bullet from a rifle. When you pull the trigger and the bullet speeds out of the barrel, there is a recoil which slams the rifle butt back against your shoulder. If the rifle were lighter and the explosion of the cartridge more powerful, the gun might go flying over your shoulder for a considerable distance.

This is the way a rocket works. The body of the rocket is like the rifle barrel; the gases ejected from its tail are like the bullet. And the power of a rocket is measured not in horsepower, but in pounds or tons of recoil—called "thrust." Because it depends on the recoil principle, this method of propulsion does not require air.

There is nothing mysterious about making use of this principle as the first step toward making our space station a reality. On the basis of present engineering knowledge, only a determined effort and the money to back it up are required. And if we don't do it, another nation—possibly less peace-minded—will. If we were to begin it immediately, and could keep going at top speed, the whole program would take about 10 years. The estimated cost would be $4,000,000,000—about twice the cost of developing the atomic bomb, but less than one quarter the price of military materials ordered by the Defense Department during the last half of 1951.

Our first need would be a huge rocket capable of carrying a crew and some 30 or 40 tons of cargo into the "two-hour" orbit. This can be built. To understand how, we again use the modern gun as an example.

A shell swiftly attains a certain speed within the gun barrel, then merely coasts through a curved path toward its target. A long-range rocket also requires its initial speed during a comparatively short time, then is carried by momentum.

For example, the V-2 rocket in a 200-mile flight is under power for only 65 seconds, during which it travels 20 miles. At the end of this 65-second period of propulsion it reaches a cut-off speed of 3,600 miles per hour; it coasts the remaining 180 miles. Logically, therefore, if we want to step up the range of a rocket, we must increase its speed during the period of powered flight. If we could step up its cut-off speed to 8,280 miles per hour, it would travel 1,000 miles.

To make a shell hit its target, the gun barrel has to be elevated and pointed in the proper direction. If the barrel were pointed straight up into the sky, the shell would climb to a certain altitude and then simply fall back, landing quite close to the gun. Exactly the same thing happens when a rocket is fired vertically. But to make the rocket reach a distant target after its vertical take-off, it must be tilted after it reaches a certain height above the ground. In rockets capable of carrying a crew and cargo, the tilting would be done by swivel-mounted rocket motors, which, by blasting sideways, would cause the rocket to veer.

* * *

Employing this method, at a cut-off speed of 17,460 miles per hour, a rocket would coast halfway around the globe before striking ground. And by boosting to just a little higher cut-off speed—4.86 miles per second or 17,500 miles per hour—its coasting path, after the power had been cut off, would match the curvature of the earth. The rocket would actually be "falling around the earth," because its speed and the earth's gravitational pull would balance exactly.

It would never fall back to the ground, for it would now be an artificial satellite, circling according to the same laws that govern the moon's path about the earth.

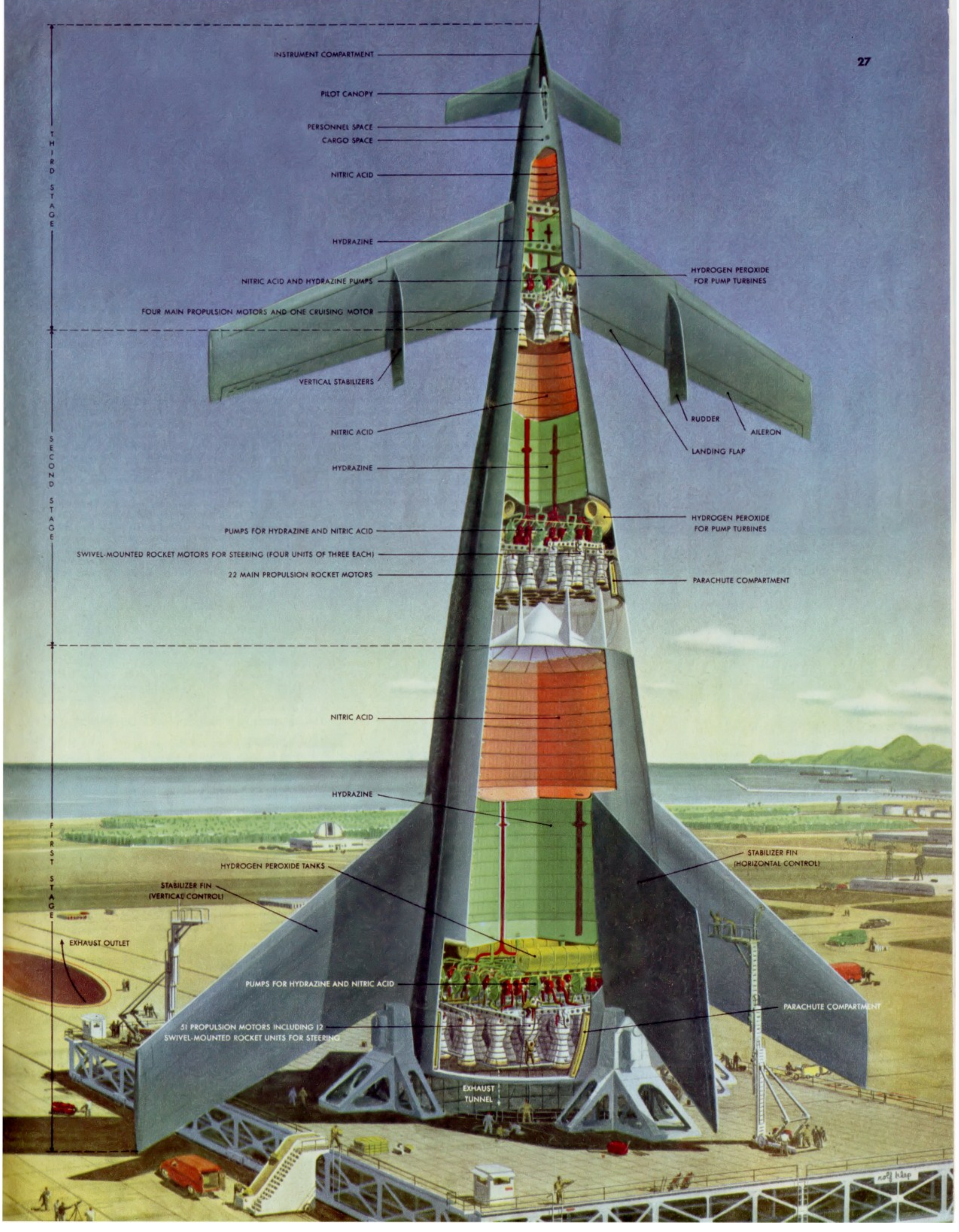
Making it do this would require delicate timing—but when you think of the split-second predictions of the eclipses, you will grant that there can hardly be any branch of natural science more accurate than the one dealing with the motion of heavenly bodies.

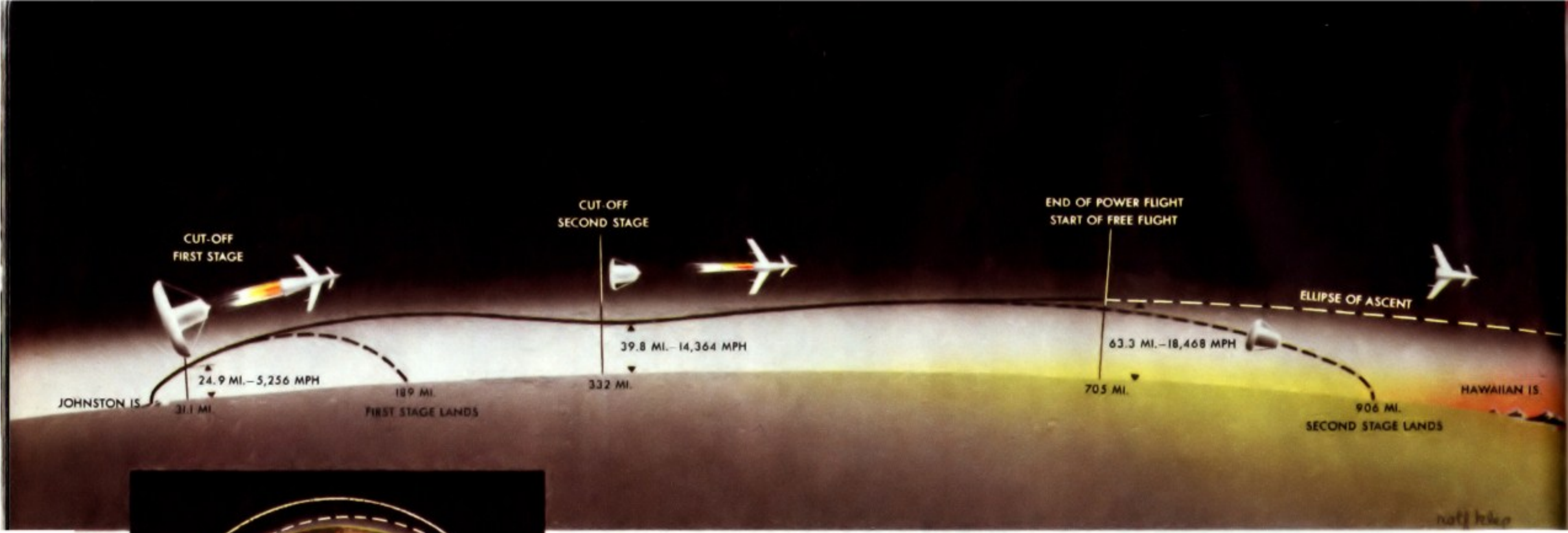
Will it be possible to attain this fantastic speed of 17,500 miles per hour necessary to reach our chosen two-hour orbit? This is almost five times as fast as the V-2. Of course, we can replace the V-2's alcohol and liquid oxygen by more powerful propellants, and even, by improving the design, reduce the rocket's dead weight and thereby boost the speed by some 40 or 50 per cent; but we would still have a long way to go.

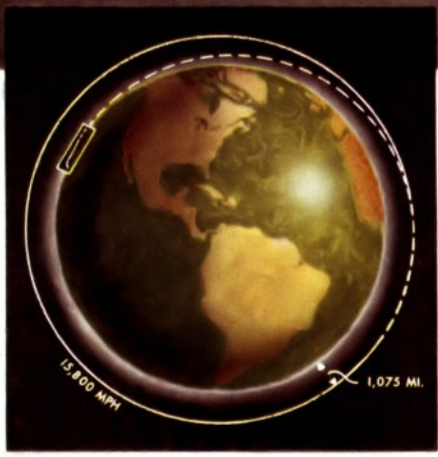
The WAC Corporal, starting from the nose of a V-2 and climbing to 250 miles, has shown us what we must do if we want to step up drastically the speed of a rocket. The WAC started its own rocket motor the moment the V-2 carrying it had reached its maximum speed. It thereby added its own speed to that already achieved by the first stage. As mentioned earlier, such a piggyback arrangement is called a "two-stage rocket"; and by putting a two-stage rocket on

Scale drawings at left show how the space station, depicted by the tiny ring at top of each sketch, will circle the earth. Actually, the man-made satellite, in the 1,075-mile orbit selected as the most desirable, will go around the world every two hours. The four drawings indicate, from top to bottom, time intervals of four hours; during each, the satellite will have made two revolutions. Thus, as the globe turns beneath them, occupants of the station will view every spot on the earth during a 24-hour span. At right is Von Braun's rocket ship design. Tall as a 24-story building, it will weigh 7,000 tons and have a 65-foot base

DRAWINGS BY ROLF KLEP


THIRD STAGE
SECOND STAGE
FIRST STAGE
INSTRUMENT COMPARTMENT
PILOT CANOPY
PERSONNEL SPACE
CARGO SPACE
NITRIC ACID
HYDRAZINE
NITRIC ACID AND HYDRAZINE PUMPS
HYDROGEN PEROXIDE FOR PUMP TURBINES
FOUR MAIN PROPULSION MOTORS AND ONE CRUISING MOTOR
VERTICAL STABILIZERS
RUDDER
AILERON
LANDING FLAP
NITRIC ACID
HYDRAZINE
HYDROGEN PEROXIDE FOR PUMP TURBINES
PUMPS FOR HYDRAZINE AND NITRIC ACID
SWIVEL-MOUNTED ROCKET MOTORS FOR STEERING (FOUR UNITS OF THREE EACH)
22 MAIN PROPULSION ROCKET MOTORS
PARACHUTE COMPARTMENT
NITRIC ACID
HYDRAZINE
STABILIZER FIN (HORIZONTAL CONTROL)
HYDROGEN PEROXIDE TANKS
STABILIZER FIN (VERTICAL CONTROL)
EXHAUST OUTLET
PUMPS FOR HYDRAZINE AND NITRIC ACID
PARACHUTE COMPARTMENT
51 PROPULSION MOTORS INCLUDING 12 SWIVEL-MOUNTED ROCKET UNITS FOR STEERING
EXHAUST TUNNEL





ROLF KLEP

Contrary to widespread notion, rocket ship does not travel straight up all the way. After covering first eight miles vertically, rocket proceeds at angle. Inset art shows complete flight path into two-hour orbit; section in rectangle marks flight segment detailed above

another, still larger, booster, we get a three-stage rocket. A three-stage rocket, then, could treble the speed attainable by one rocket stage alone (which would give it enough speed to become a satellite).

In fact, it could do even better. The three-stage rocket may be considered as a rocket with three sets of motors; after the first set has given its utmost, and has expired, it is jettisoned—and so is the second set, in its turn. The third stage, or nose, of the rocket continues on its way, relieved of all that excess weight.

* * *

Besides the loss of the first two stages, other factors make the rocket's journey easier the higher it goes. First, the atmosphere is dense, and tends to hinder the passage of the rocket; once past it, the going is faster. Second, the rocket motors operate more efficiently in the rarefied upper layers of the atmosphere. Third, after passing through the densest portion of the atmosphere, the rocket no longer need climb vertically.

Imagine the size of this huge three-stage rocket ship: it stands 265 feet tall, approximately the height of a 24-story office building. Its base measures 65 feet in diameter. And the over-all weight of this monster rocket ship is 14,000,000 pounds, or 7,000 tons—about the same weight as a light destroyer.

Its three huge power plants are driven by a combination of nitric acid and hydrazine, the latter being a liquid compound of nitrogen and hydrogen, somewhat resembling its better-known cousin, ammonia. These propellants are fed into the rocket motors by means of turbopumps.

Fifty-one rocket motors, pushing with a combined thrust of 14,000 tons, power the first stage (tail section). These motors consume a total of 5,250 tons of propellants in the incredibly short time of 84 seconds. Thus, in less than a minute and a half, the rocket loses 75 per cent of its total original weight!

The second stage (middle section), mounted on top of the first, has 34 rocket motors with a total thrust of 1,750 tons, and burns 770 tons of propellants. It operates for only 124 seconds.

The third and final stage (nose section)—carrying the crew, equipment and pay load—has five rocket motors with a combined thrust of 220 tons. This "body" or cabin stage of the rocket ship carries 90 tons of propellants, including ample reserves for the return trip to earth. In addition, it is capable of carrying a cargo or pay load of about 36 tons into our two-hour orbit 1,075 miles above sea level. (Also, in expectation of the return trip, the nose section will have wings something like an airplane's. They will be used only during the descent, after re-entering the earth's atmosphere.)

Years before the actual take-off, smaller rocket ships, called instrument carriers, will have been sent up to the two-hour orbit. They will circle there, sending back information by the same electronic method already in use with current rockets. Based on the data thus obtained, scientists, astronomers, and engineers, along with experts from the armed forces, will plan the complete development of the huge cargo-carrying rocket ship.

The choice of the take-off site poses another problem. Because of the vast amount of auxiliary equipment—such as fuel storage tanks and machine shops, and other items like radio, radar, astronomical and meteorological stations—an extensive area is required. Furthermore, it is essential, for reasons which will be explained later, that the rocket ship fly over the ocean during the early part of the flight. The tiny U.S. possession known as Johnston Island, in the Pacific, or the Air Force Proving Ground at Cocoa, Florida, are presently considered by the experts to be suitable sites.

At the launching area, the heavy rocket ship is assembled on a great platform. Then the platform is wheeled into place over a tunnel-like "jet deflector" which drains off the fiery gases of the first stage's rocket motors. Finally, with a mighty roar which is heard many miles away, the rocket ship slowly takes off—so slowly, in fact, that in the first second it travels less than 15 feet. Gradually, however, it begins to pick up speed, and 20 seconds later it has disappeared into the clouds.

Because of the terrific acceleration which will be experienced one minute later, the crew—located, of course, in the nose—will be lying flat in "contour" chairs at take-off, facing up. Throughout the whole of its flight to the two-hour orbit, the rocket is under the control of an automatic gyropilot. The timing of its flight and the various maneuvers which take place have to be so precise that only a machine can be trusted to do the job.

After a short interval, the automatic pilot tilts the rocket into a shallow path. By 84 seconds after take-off, when the fuels of the first stage (tail section) are nearly exhausted, the rocket ship is climbing at a gentle angle of 20.5 degrees.

When it reaches an altitude of 24.9 miles it will have a speed of 1.46 miles per second, or 5,256 miles per hour. To enable the upper stages to break away from the tail or first stage, the tail's power has to be throttled down to almost zero. The motors of the second stage now begin to operate, and the connection between the now-useless first stage and the rest of the rocket ship is severed. The tail section drops behind, while the two upper stages of the rocket ship forge ahead.

After the separation, a ring-shaped ribbon parachute, made of fine steel wire mesh, is automatically released by the first stage. This chute has a diameter of 217 feet and gradually it slows down the tail section. But under its own momentum, this empty hull continues to climb, reaching a height of 40 miles before slowly descending. It is because the tail section could be irreparably damaged if it struck solid ground (and might be dangerous, besides) that the initial part of the trip must be over the sea. After the first stage lands in the water, it is collected and brought back to the launching site.

The same procedure is repeated 124 seconds later. The second stage (middle section) is dropped into the ocean. The rocket ship by this time has attained an altitude of 40 miles and is 332 miles from the take-off site. It also has reached a tremendous speed—14,364 miles per hour.

Now the third and last stage—the nose section or cabin-equipped space ship proper—proceeds under the power of its own rocket motors. Just 84 seconds after the dropping of the second stage, the rocket ship, now moving at 18,468 miles per hour, reaches a height of 63.3 miles above the earth.

At this point we must recall the comparison between the rocket and the coasting rifle shell to understand what occurs. The moment the rocket reaches a speed of 18,468 miles per hour, at an altitude of 63.3 miles, the motors are cut off, even though the fuel supply is by no means exhausted. The rocket ship continues on an unpowered trajectory until it reaches 1,075 miles above the earth. This is the high point, or "apogee"; in this case it is exactly halfway around the globe from the cut-off place. The rocket ship is now in the two-hour orbit where we intend to build the space station.

* * *

Just one more maneuver has to be performed, however. In coasting up from 63.3 miles to 1,075 miles, the rocket ship has been slowed by the earth's gravitational pull to 14,770 miles per hour. This is not sufficient to keep the ship in our chosen orbit. If we do not increase the speed, the craft will swing back halfway around the earth to the 63.3-mile altitude. Then it would continue on past the earth until, as it curves around to the other side of the globe, it would be back at the same apogee, at the 1,075-mile altitude.

The rocket ship would already be a satellite and behave like a second moon in the heavens, swinging on its elliptical path over and over for a long time. One might well ask: Why not be satisfied with this? The reason is that part of this particular orbit is in the atmosphere at only 63.3 miles. And while the air resistance there is very low, in time it would cause the rocket ship to fall back to earth.

Our chosen two-hour orbit is one which, at *all* points, is exactly 1,075 miles above the earth. The last maneuver, which stabilizes the rocket ship in this orbit, is accomplished by turning on the rocket motors for about 15 seconds. The velocity is thus increased by 1,030 miles per hour, bringing the total speed to 15,800 miles per hour. This is the speed necessary for remaining in the orbit permanently. We have reached our goal.

An extraordinary fact about the flight from the earth is this: it has taken only 56 minutes, during which the rocket ship was powered for only five minutes.

From our vantage point, 1,075 miles up, the earth, to the rocket ship's crew, appears to be rotating once every two hours. This apparent fast spin of the globe is the only indication of the tremendous speed at which the rocket ship is moving. The earth, of course, still requires a full 24 hours to complete one revolution on its axis, but the rocket ship is making 12 revolutions around the earth during the time the earth makes one.

We now begin to unload the 36 tons of cargo which we have carried up with us. But how and where shall we unload the material? There is nothing but the blackness of empty space all around us.

We simply dump it out of the ship. For the cargo, too, has become a satellite! So have the crew members. Wearing grotesque-looking pressurized suits and carrying oxygen for breathing, they can now leave the rocket ship and float about unsupported.

Just as a man on the ground is not conscious of the fact that he is moving with the earth around the sun at the rate of 66,600 miles per hour, so the men in the space ship are not aware of the fantastic speed with which they are going around the earth. Unlike men on the ground, however, the men in space do not experience any gravitational pull. If one of them, while working, should drift off into space, it will be far less serious than slipping off a scaffold. Drifting off merely means that the man has acquired a very slight speed in an unforeseen direction.

He can stop himself in the same manner in which any speed is increased or stopped in space—by reaction. He might do this, theoretically, by firing a revolver in the direction of his inadvertent movement. But in actual practice the suit will be equipped with a small rocket motor. He could also propel himself by squirting some compressed oxygen from a tank on his back. It is highly probable, however, that each crew member will have a safety line securing him to the rocket as he works. The tools he uses will also be secured to him by lines; otherwise they might float away into space.

* * *

The spacemen—for that is what the crew members now are—will begin sorting the equipment brought up. Floating in strange positions among structural units and machinery, their work will proceed in absolute silence, for there is no air to carry sound. Only when two people are working on the same piece of material, both actually touching it, will one be able to hear the noises made by another, because sound is conducted by most materials. They will, however, be able to converse with built-in "walkie-talkie" radio equipment. The cargo moves easily; there is no weight, and no friction. To push it, our crew member need only turn on his rocket motor (if he shoved a heavy piece of equipment without rocket power, he might fly backward!).

Obviously the pay load of our rocket ship—though equivalent to that of two huge Super Constellations—will not be sufficient to begin construction of the huge, three-decked, 250-foot-wide space station. Many more loads will be required. Other rocket ships, all timed to arrive at the same point in a continuous procession as the work progresses, will carry up the remainder of the prefabricated satellite. This will be an expensive proposition. Each rocket trip will cost more than half a million dollars *for propellants alone*. Thus, weight and shipping space limitations will greatly affect the specifications of a space station.

In at least one design, the station consists of 20 sections made of flexible nylon-and-plastic fabric. Each of these sections is an independent unit which later, after assembly into a closed ring, will provide compartmentation similar to that found in submarines. To save shipping space, these sections will be carried to the orbit in a collapsed condition. After the "wheel" has been put together and sealed, it will then be inflated like an automobile tire to slightly less than normal atmospheric pressure. This pressure will not only provide a breathable atmosphere within the ring but will give the whole structure its necessary rigidity. The atmosphere will, of course, have to be renewed as the men inside exhaust it.

On solid earth, most of our daily activities are conditioned by gravity. We put something on a table and it stays there, because the earth attracts it, pulling it against the table. When we pour a glass of milk, gravity draws it out of the bottle and we catch the falling liquid in a glass. In space, however, everything is weightless. And this includes man.

This odd condition in no way spells danger, at least for a limited period of time. We experience weightlessness for short periods when we jump from a diving board into a pool. To be sure, there are some medical men who are concerned at the prospect of permanent weightlessness—not because of any known danger, but because of the unknown possibilities. Most experts discount these nameless fears.

However, there can be no doubt that permanent weightlessness might often prove inconvenient. What we require, therefore, is a "synthetic" gravity within the space station. And we can produce centrifugal force—which acts as a substitute for gravity—by making the "wheel" slowly spin about its hub (a part of which can be made stationary).

To the space station proper, we attach a tiny rocket motor which can produce enough power to rotate the satellite. Since *(Continued on page 72)*

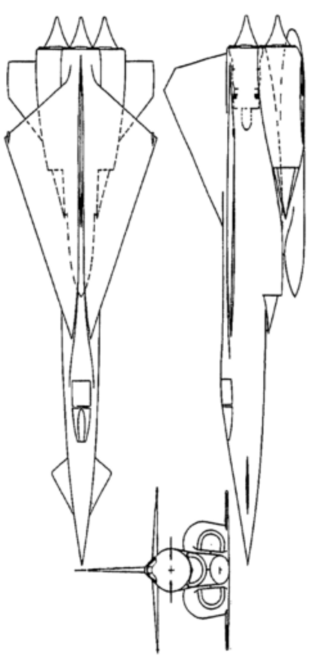
PAINTING BY CHESLEY BONESTELL

Skin of rocket ship's third stage (shown over Cape Town, South Africa) glows red hot on return trip. Phenomenon does not occur during ascent

APR Corner, Mini Edition: Mach 3 VTOL Aircraft for Submarines

By Scott Lowther

In 1958, Boeing-Wichita designed a Mach 3 aircraft specifically to go with the AN-1 and AN-2 submarine aircraft carriers (also Boeing designed). While no designation for the aircraft has been found, data has. They were to be 70 ft long overall, with a wingspan of 21.2 ft. GTOW was 32,630 lbs. VTO was provided by a "Magic Carpet," an unmanned booster aircraft that attached to the aircrafts belly and was also recoverable and reusable. Both aircraft were recovered in the same fashion as the X-13. Missions included interception and bombardment (likely nuclear).



More on this aircraft, the AN-1 and AN-2 and other submarine aircraft carrier designs can be found in issue V1N6 of Aerospace Projects Review.

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Crossing the Last Frontier

CONTINUED FROM PAGE 29

there is no resistance which would slow the "wheel" down, the rocket motor does not have to function continuously. It will operate only long enough to give the desired rotation. Then it is shut off.

Now, how fast would we like our station to spin? That depends on how much "synthetic gravity" we want. If our 250-foot ring performed one full revolution every 12.3 seconds, we would get a synthetic gravity equal to that which we normally experience on the ground. This is known as "one gravity" or, abbreviated, "1 g." For a number of reasons, it may be advantageous not to produce one full "g." Consequently, the ring can spin more slowly; for example, it might make one full revolution every 22 seconds, which would result in a "synthetic gravity" of about one third of normal surface gravity.

The centrifugal force created by the slow spin of the space station forces everything out from the hub. No matter where the crew members sit, stand or walk inside, their heads will always point toward the hub. In other words, the inside wall of the "wheel's" outer rim serves as the floor.

* * *

How about the temperature within the space station? Maybe you, too, have heard the old fairy tale that outer space is extremely cold—absolute zero. It's cold, all right, but not that cold—and not in the satellite. The ironical fact is that the engineering problem in this respect will be to keep the space station comfortably cool, rather than to heat it up. In outer space, the temperature of any structure depends entirely on its absorption and dissipation of the sun's rays. The space station happens to be in the unfortunate position of receiving not only direct heat from the sun but also reflected heat from the earth.

If we paint the space station white, it will then absorb a minimum of solar heat. Being surrounded by a perfect vacuum, it will be, except for its shape, a sort of thermos bottle, which keeps hot what is hot, and cold what is cold.

In addition, we can scatter over the surface of the space station a number of black patches which, in turn, can be covered by shutters closely resembling white Venetian blinds. When these blinds are open on the sunny side, the black patches will absorb more heat and warm up the station. When the blinds are open on the shaded side, the black patches will radiate more heat into space, thereby cooling the station. Operate all these blinds with little electric motors, hook them to a thermostat, and tie the whole system in with the station's air-conditioning plant—and there's your temperature control system.

Inflating the space station with air will, as we have indicated, provide a breathable atmosphere for a limited time only. The crew will consume oxygen at a rate of approximately three pounds per man per day. At intervals, therefore, this life-giving oxygen will have to be replenished by supply ships from earth. At the same time, carbon dioxide and toxic or odorous products must be constantly removed from the air-circulation system. The air must also be dehumidified, inasmuch as through breathing and perspiration each crew member will lose more than three pounds of water per day to the air system (just as men do on earth).

This water can be collected in a dehumidifier, from which it can economically be salvaged, purified and reused.

Both the air-conditioning and water-recovery units need power. So do the radar systems, radio transmitters, astronomical equipment, electronic cookers and other machinery. As a source for this power we have the sun. On the earth, solar power is reliable in only a few places where clouds rarely obscure the sky, but in space there are no clouds, and the sun is the simplest answer to the station's power needs.

Our power plant will consist of a condensing mirror and a boiler. The condensing mirror will be a highly polished sheet metal trough running around the "wheel." The position of the space station can be arranged so that the side to which the mirror is attached will always point toward the sun. The mirror then focuses the sun's rays on a steel pipe which runs the length of the mirrored trough. Liquid mercury is fed under pressure into one end of this pipe and hot mercury vapor is taken out at the other end. This vapor drives a turbogenerator which produces about 500 kilowatts of electricity.

Of course, the mercury vapor has to be used over and over again, so after it has done its work in the turbine it is returned to the "boiler" pipe in the mirror. Before this can be done, the vapor has to be condensed back into liquid mercury by cooling. This is achieved by passing the vapor through pipes located behind the mirror in the shade. These pipes dissipate the heat of the vapor into space.

Thus we have within the space station a complete, synthetic environment capable of sustaining man in space. Of course, man will face hazards—some of them, like cosmic radiation and possible collision with meteorites, potentially severe. These problems are being studied, however, and they are considered far from insurmountable.

Our "wheel" will not be alone in the two-hour orbit. There will nearly always be one or two rocket ships unloading supplies. They will be parked some distance away, to avoid the possibility of damaging the space station by collision or by the blast from the vehicle's rocket motors. To ferry men and materials from rocket ship to space station, small rocket-powered metal craft of limited range, shaped very much like overgrown watermelons, will be used. These "space taxis" will be pressurized and, after boarding them, passengers can remove their space suits.

On approaching the space station, the tiny shuttle-craft will drive directly into an air lock at the top or bottom of the stationary hub. The space taxi will be built to fit exactly into the air lock, sealing the opening like a plug. The occupants can then enter the space station proper without having been exposed to the airlessness of space at any time since leaving the air lock of the rocket ship.

* * *

There will also be a space observatory, a small structure some distance away from the main satellite, housing telescopic cameras for taking long-exposure photographs. (The space station itself will carry extremely powerful cameras, but its spin, though slow, will permit only short exposures.) The space observatory will not be manned, for if it were, the movements of an operator would disturb the alignment. Floating outside the structure in space suits, technicians will load a camera with special plates or film, and then withdraw. The camera will be aimed and the shutter snapped by remote radio control from the space station.

Most of the pictures taken of the earth, however, will be by the space station's cameras. The observatory will be used mainly to record the outer reaches of the universe, from the neighboring planets to the distant galaxies of stars. This mapping of the heavens will produce results which no observatory on earth could possibly duplicate. And, while the scientists are probing the secrets of the universe with their cameras, they will also be planning another trip through space—this time to examine the moon.

Suppose we take the power plant out of our rocket ship's last stage and attach it to a lightweight skeleton frame of aluminum girders. Then we suspend some large collapsible fuel containers in this structure and fill them with propellants. Finally, we connect some plumbing and wiring and top the whole structure with a cabin for the crew, completely equipped with air and water regeneration systems, and navigation and guidance equipment.

The result will be an oddly shaped vehicle, not much larger than the rocket ship's third stage, but capable of carrying a crew of several people to a point beyond the rear side of the moon, then back to the space station. This vehicle will bear little resemblance to the moon rockets depicted in science fiction. There is a very simple reason: conventional streamlining is not necessary in space.

The space station, as mentioned previously, has a speed of 15,840 miles per hour. Our round-the-moon ship, to leave the two-hour orbit, has to have a speed of 22,100 miles per hour, to cover the 238,000-mile distance to the moon. This additional speed is acquired by means of a short rocket blast, lasting barely two minutes. This throws the round-the-moon ship into a long arc or ellipse, with its remotest point beyond the moon. The space ship will then coast out this distance, unpowered, like a thrown stone. It will lose speed all along the way, due to the steady action of the earth's gravitational pull—which, though weakening with distance, extends far out into space.

Roughly five days after departure, the space ship will come almost to a standstill. And if we have timed our departure correctly, the moon will now pass some 200 miles below us, with the earth on its far side. On this one trip we can photograph most of the unknown half of the moon, the half which has never been seen from the earth. Furthermore, we now have an excellent opportunity to view the earth from the farthest point yet; at this distance, it appears not unlike a miniature reproduction of itself (from the vicinity of the moon, the earth will look about four times as large as the full moon does to earth-bound man).

It is not necessary to turn on the space ship's motors for the return trip. The moon's gravity is too slight to affect us substantially; like the shell which was fired vertically, we simply "fall back" to the space station's orbit. The long five-day "fall" causes the space ship to regain its initial speed of 22,100 miles per hour. This is 6,340 miles per hour faster than the speed of the space station, but, as we have fallen back tail first, we simply turn on the motors for just two minutes, which reduces our speed to the correct rate which permits us to re-enter the two-hour orbit.

* * *

Besides its use as a springboard for the exploration of the solar system, and as a watchdog of the peace, the space station will have many other functions. Meteorologists, by observing cloud patterns over large areas of the earth, will be able to predict the resultant weather more easily, more accurately and further into the future. Navigators on the seas and in the air will utilize the space station as a "fix," for it will always be recognizable.

But there will also be another possible use for the space station—and a most terrifying one. It can be converted into a terribly effective atomic bomb carrier.

Small winged rocket missiles with atomic war heads could be launched from the station in such a manner that they would strike their targets at supersonic speeds. By simultaneous radar tracking of both missile and target, these atomic-headed rockets could be accurately guided to any spot on the earth.

In view of the station's ability to pass over all inhabited regions on earth, such atom-bombing techniques would offer the satellite's builders the most important tactical and strategic advance in military history. Furthermore, its observers probably could spot, in plenty of time, any attempt by an enemy to launch a rocket aimed at colliding with the giant "wheel" and intercept it.

We have discussed how to get from the ground to the two-hour orbit, how to build the space station and how to get a look at the unknown half of the moon by way of a round trip from our station in space. But how do we return to earth?

Unlike the ascent to the orbit, which was controlled by an automatic pilot, the descent is in the hands of an experienced "space pilot."

To leave the two-hour orbit in the third stage, or nose section, of the rocket ship, the pilot slows down the vehicle in the same manner in which the returning round-the-moon ship slowed down. He reduces the speed by 1,070 miles per hour. Unpowered, the rocket ship then swings back toward the earth. After 51 minutes, during which we half circumnavigate the globe, the rocket ship enters the upper layers of the atmosphere. Again, it has fallen tail first; now the pilot turns it so that it enters the atmosphere nose first.

* * *

About 50 miles above the earth, due to our downward, gravity-powered swing from the space station's orbit, our speed has increased to 18,500 miles per hour. At this altitude there is already considerable air resistance.

With its wings and control surfaces, the rocket closely resembles an airplane. At first, however, the wings do not have to carry the rocket ship. On the contrary, they must prevent it from soaring out of the atmosphere and back into the space station's orbit again.

His eyes glued to the altimeter, the pilot will push his control stick forward and force the ship to stay at an altitude of exactly 50 miles. At this height, the air resistance gradually slows the rocket ship down. Only then can the descent into the denser atmosphere begin; from there on, the wings bear more and more of the ship's weight. After covering a distance of about 10,000 miles in the atmosphere, the rocket's speed will still be as high as 13,300 miles per hour. After another 3,000 miles, the speed will be down to 5,760 miles per hour. The rocket ship will by now have descended to a height of 29 miles.

The progress of the ship through the upper atmosphere has been so fast that air friction has heated the outer metal skin of body and wings to a temperature of about 1,300 degrees Fahrenheit. The rocket ship has actually turned color, from steel blue to cherry red! This should not cause undue concern, however, inasmuch as we have heat-resistant steels which can easily endure such temperatures. The canopy and windows will be built of double-paned glass with a liquid coolant flowing between the panes. And the crew and cargo spaces will be properly heat-insulated and cooled by means of a refrigerator-type air-conditioning system. Similar problems have already been solved, on a somewhat smaller scale, in present-day supersonic airplanes.

At a point 15 miles above the earth, the rocket ship finally slows down to the speed of sound—roughly 750 miles per hour. From here on, it spirals down to the ground like a normal airplane. It can land on conventional landing gear, on a runway adjacent to the launching site. The touch-down speed will be approximately 65 miles per hour, which is less than that of today's air liners. And if the pilot should miss the runway, a small rocket motor will enable him to circle once more and make a second approach.

After a thorough checkup, the third stage will be ready for another ascent into the orbit. The first and second stages (or tail and middle sections), which were parachuted down to the ocean, have been collected in specially made seagoing dry docks. They were calculated to fall at 189 miles and 906 miles respectively from the launching site. They will be found relatively undamaged, because at a point 150 feet above the water their parachute fall was broken by a set of cordite rockets which were automatically set off by a proximity fuse.

They, too, undergo a thorough inspection with some replacement of parts damaged by the ditching. Then all three stages are put together again in a towerlike hangar, right on the launching platform, and, after refueling and a final check, platform and ship are wheeled out to the launching site—ready for another journey into man's oldest and last frontier: the heavens themselves. THE END

A self-contained community, this outpost in the sky will provide all of man's needs, from air conditioning to artificial gravity

WHEN man first takes up residence in space, it will be within the spinning hull of a wheel-shaped structure, rotating around the earth much as the moon does. Life will be cramped and complicated for space dwellers; they will exist under conditions comparable to those on a modern submarine. This painting, which is scientifically accurate, shows how the spacemen will live and work inside their whirling station.

The wheel's movement around its hub will provide centrifugal force as a substitute for gravity in weightless space; however, this "synthetic gravity" will not be equal in all parts of the station, since the amount of spin will decrease toward the center. Thus, the topmost of the three decks (the one on the inside of the wheel) will have the least gravity, and the hub itself will have virtually none.

At the extreme left of the painting (below), on the top deck, is the communications center, which maintains radio contact with the earth, with rocket ships in space, and with the space taxis that carry men from rocket ship to space station. Below the communications room, meteorologists chart the weather for the entire earth; on the lowest deck at extreme left is a bunk room.

Next door to the communications and weather sections is the earth observation center, occupying two decks. On the top deck is a large movable map on which "ground zero," the territory the station is passing over at the moment, is spotted. Immediately below the map is a telescopic enlargement of ground zero. Under this, on the center deck, are additional telescopic screens showing other territory (figures over each screen refer to the amount of territory covered by the picture, not to the apparent distance away from the scene).

The electronic computer on the top deck, between the earth observation and celestial observation centers, solves complicated mathematical problems. The large screen in the celestial observation room enables astronomers to study enlarged photographs taken from the satellite's tiny sister station, the observatory. The bottom deck contains a photographic darkroom and part of the system which recovers and purifies waste water.

The next section over is devoted to the handling of cargo. Material arrives from the hub by elevator, and is distributed from the loading room in accordance with decisions made by the weight control center, which is charged with preserving the station's balance. Fuel storage and air-conditioning return ducts are located under this area.

The layers of skin enclosing the space station are shown covering part of the loading area. The outer skin, or meteor bumper, is attached to the inner skin by studs. The view ports are of plastic, tinted to guard against radiation; protective lids are lowered when the windows are not in use. The two black squares, which absorb the sun's heat and warm the satellite, have shutters to control heat absorption. On the meteor bumper wall are hook-on rings, to which spacemen tie lines while outside, to keep from floating away into space.

The sections beyond the pump room (top deck) form the heart of the system which keeps the space station supplied with air. The air control room regulates air pressures in the satellite. The components of the air mixture are determined by chemists in the air testing laboratory. In the room housing the air-conditioning machinery, the interior wall of the space station's inner rim is cut away to show secondary cables and ducts, which furnish power, air and the like, when the main system (right, overhead) fails.

The trough and pipe in the extreme upper-right corner of the picture are a part of the satellite's power plant. The trough is polished to catch the rays of the sun; the heat thus obtained is picked up by mercury in the tube. The mercury, emerging as hot vapor in the room below, drives a turbo-generator.

Inside the shaft which leads to the satellite's hub is a landing net to assist men in moving into and out of the gravity-free area. Since the hub is the center of all entrances, departures and loadings, it is kept fairly clear, except for the space station's supply of pressurized suits. At the top and bottom of the rotating hub are turrets which can be turned so space taxis can land in the bell-shaped landing berths. The taxi's body seals the turret shut, and the men move to the space station proper through air locks.

This drawing, of course, shows only a part of the space station. Its many other sections also contain equipment, supplies and living quarters. Balance must be carefully maintained, with each section painstakingly adjusted to the same weight as the section diametrically opposite it on the wheel. If this were not done, the revolving station might wobble, making the synthetic gravity uneven, disturbing the delicate measurements of the scientists within—and weakening the entire structure dangerously.

Station in Space

By WILLY LEY

Noted Rocket Scientist and Author

PAINTING BY FRED FREEMAN

The Heavens Open

By Dr. FRED L. WHIPPLE

Chairman, Department of Astronomy, Harvard University

Once above the atmosphere which blindfolds our scientists now, a revolution will take place in astronomy. Man will, for the first time, get a good, clear look at the universe

IN MANY respects, today's astronomers might as well be blindfolded in a deep, dark coal mine. The earth's atmosphere, even on a perfectly clear day or night, blankets out many of the secrets of the universe. Details of the surface of the moon, planets and star groups disappear in a dancing blur because the atmosphere is never really quiet. The extremely significant far ultraviolet light, the X rays and gamma rays of space are indiscernible because the atmosphere permits free passage only to the visible light rays.

The establishment of a telescope and observatory in space will end this era of blindness. It will be as revolutionary to science as the invention of the telescope itself.

The sun, for example, photographed from the space station by X rays, will be an amazing sight. Astronomers have deduced that it very probably will look like a mottled, irregular sunflower. And what we now see as the sun's disk will, in all likelihood, prove to be only the central core of a large fuzzy-looking ball. It will be covered with bright specks and pulsing streaks, while the usually invisible corona will show up as the main source of light.

Similarly, familiar star constellations may look very strange when photographed from the space station or space observatory with plates sensitive to all the wave lengths of ultraviolet light.

Stars send ultraviolet as well as visible light. Some, however, radiate mostly ultraviolet. These appear weak to the eye, but will be exceedingly bright to the special camera. Those which send out very little ultraviolet light will hardly show on the special photographic plates. The Milky Way itself might be markedly changed—I wish I knew just how.

What is even more fascinating to the astronomer than acquiring "full vision" is the fact that space travel will permit him to change position in space. For instance, there is our moon, relatively near and under observation since the first telescope was built. But the moon always turns the same side toward the earth, and almost one half of its total surface has never been seen by man.

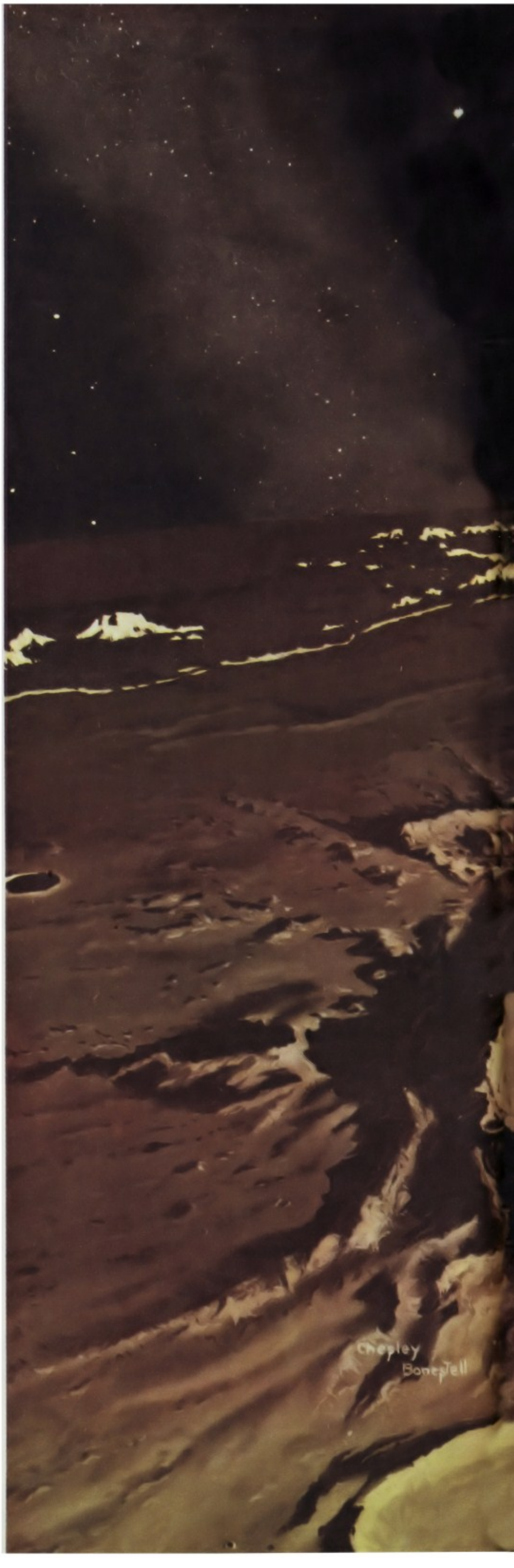
What are the first astronomers who make a round-the-moon journey going to see on that completely unknown portion? Will they find mountains, plains and craters like those we see on the side visible to us now? Or will they find a plain, serrated with jagged canyons—or a landscape unmarked by anything? And were the moon's gigantic craters formed by some type of volcanic action or are they a result of collision with flying mountains from space? Is there really a thick layer of dust covering the moon's surface? Observation from a space ship will give us conclusive answers to all these questions.

The astronomers in the space station will also have a very practical job awaiting them. When the sun becomes temperamental, as it frequently does, it develops gigantic storms on its surface, emitting excessive amounts of ultraviolet light and X rays, and even ejecting high-speed atoms. Although they cannot be observed directly, these emanations knock out our long-range radio communications, cause transcontinental teletypes to go berserk and sometimes even burn out long-range telephone and power cables.

There is little doubt that our space station astronomers, maintaining a 24-hour surveillance of the sun and all its radiations, not only will find the explanation for these solar storms but will learn to predict them in advance. Preparations could then be made to protect our electronic equipment.

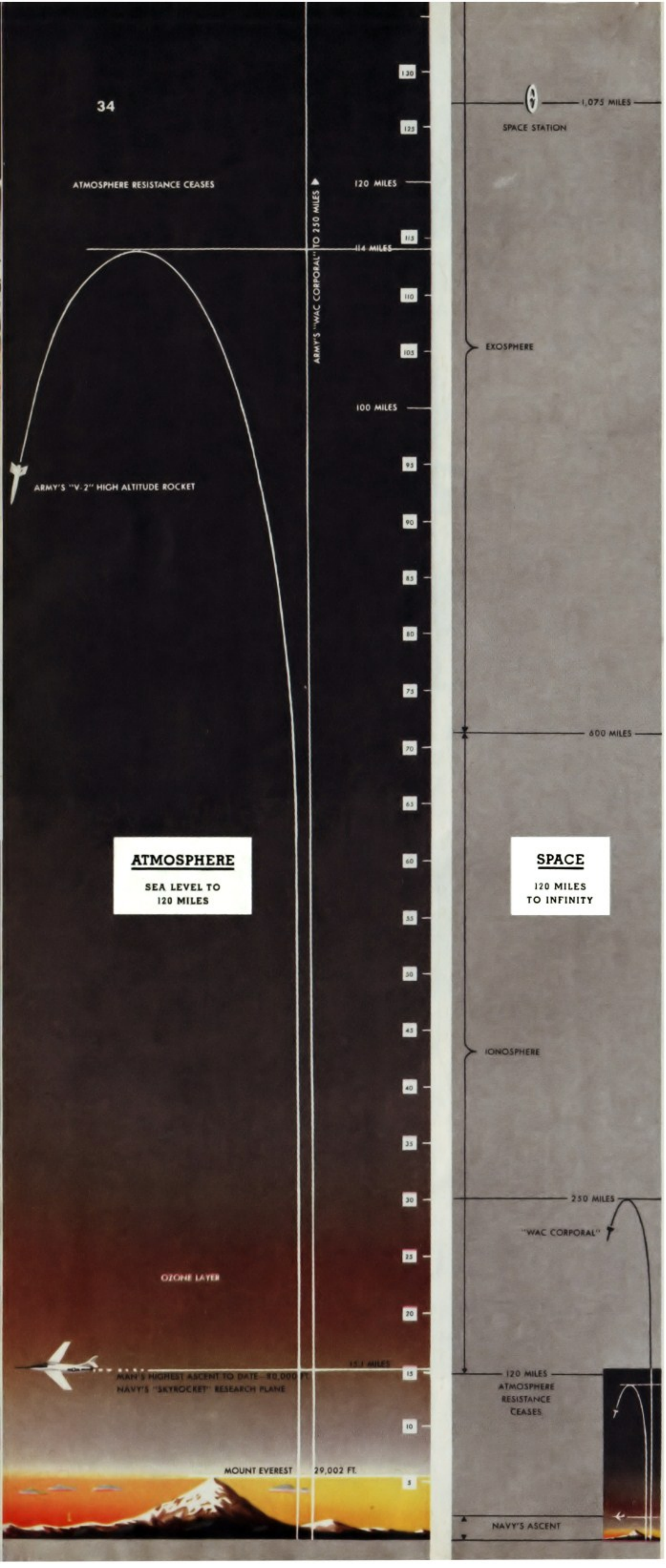
I can mention only a few more projects which will fascinate the astronomers of space. Among them: (1) the mysteries of the superhot and exploding stars; (2) the composition of the atmospheres of other planets, such as Mars; (3) details of the surfaces of other planets (which may offer evidence concerning possible life there); (4) analysis of the great dust and gas clouds of the Milky Way, where stars are born; (5) mapping of similar regions in other great galaxies comprising billions of stars. They should discover important clues regarding the expansion of the universe, its dimensions and its nature.

The astronomer will no longer be limited to seeing as "through a glass, darkly." The universe will spread out clearly before him. ▲▲▲



Specially designed round-the-moon ship hovers 200 miles above lunar surface as space scientists take close-up photographs. One-way journey from station in space will take five days to cover 239,000 miles. Never-seen face of the moon is to right. Trip will have to be timed so that sun lights hidden side

PAINTING BY CHESLEY BONESTELL



This Side of Infinity

By Dr. JOSEPH KAPLAN

Professor of Physics, Institute of Geophysics, University of California

WE ARE living at the bottom of a great envelope of air which provides us with life-giving oxygen and water, protects us from the harmful effects of the sun's ultraviolet rays, and shields us from the high-speed projectiles called meteorites. Without this envelope, all life, as we know it, would cease.

This protective covering around the earth is the atmosphere, a mixture of about 20 per cent oxygen, almost 80 per cent nitrogen, and minute quantities of other gases. The mixture is thickest at sea level; with increasing altitude, it becomes thinner and thinner until eventually, for all practical purposes, we may say that it disappears. At 10,000 feet, the air is so thin that man usually has difficulty breathing. Over 20,000 feet, death awaits anyone not carrying oxygen. Over the years, scientists have found it convenient to divide the atmosphere into levels, as shown in the accompanying charts. These layers have distinctive properties which make them of special interest to particular branches of science. The first layer, from sea level to an altitude of eight miles, is of primary scientific importance to meteorologists, for it is here that all weather occurs. In 1898, the French meteorologist, Léon P. Teisserenc de Bort, named it the troposphere.

Until recent times, aeronautical engineers also devoted their main attention to the troposphere. Then, with the development of airplanes that could climb to an altitude of 60,000 feet, they began to show interest in the next level, the stratosphere (also named by De Bort), which extends from eight to 60 miles up. Extremely powerful winds have been found in this layer of the atmosphere, moving at the entirely unexpected rate of 200 miles per hour.

Here, too, was found a section 10 miles thick which attracted the special attention of physicists. For this layer contains an unusually high percentage of ozone (another form of oxygen) produced by the interaction of the sun's ultraviolet rays and oxygen. It is this ozone layer, which they themselves create, that prevents the ultraviolet rays from striking earth and killing all life.

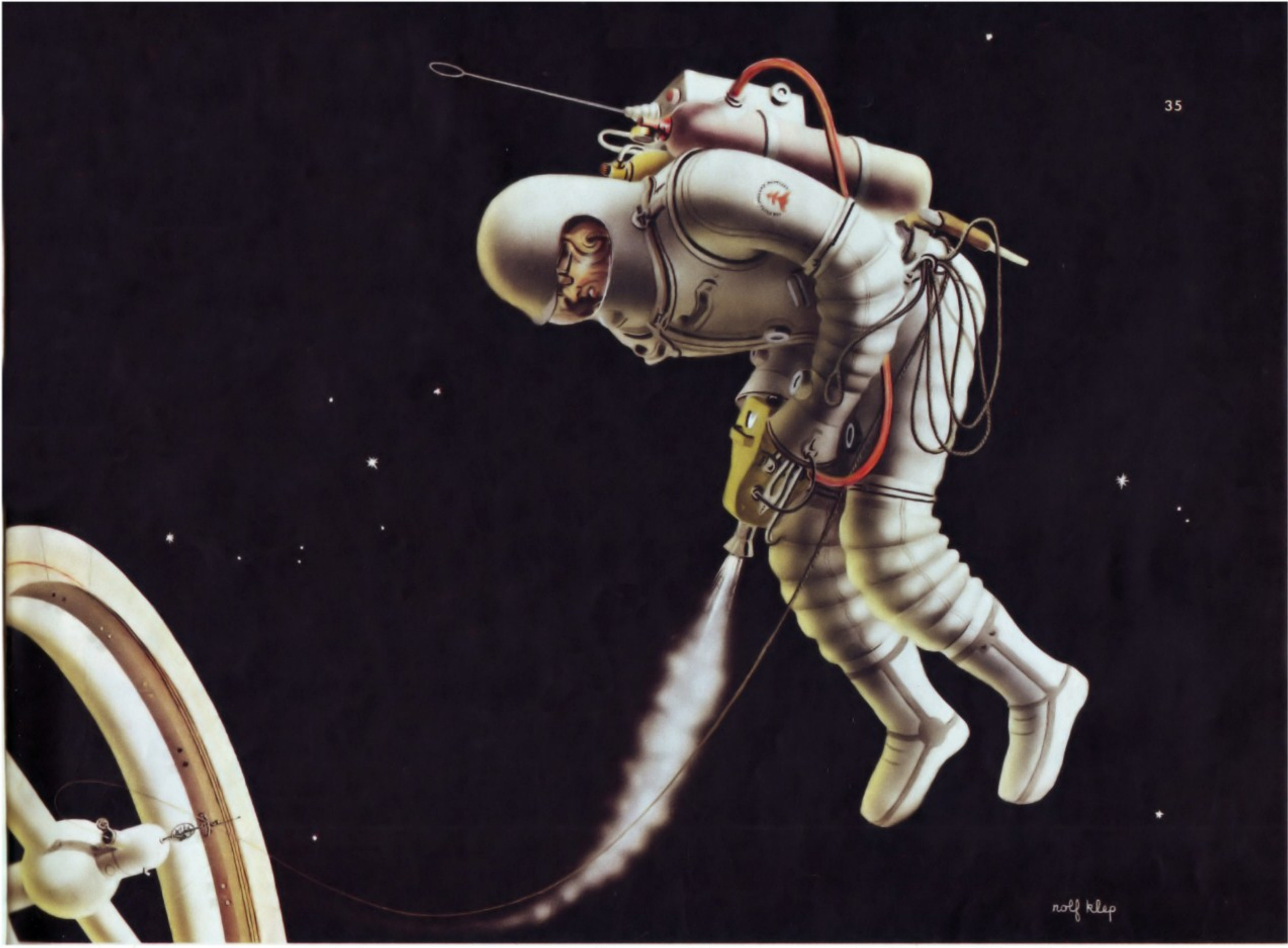
The thermometer, which shows widely varying temperatures on earth, suddenly stabilizes at the lower edge of the stratosphere, reading a constant 67 degrees below zero. Not long ago, it was believed the whole stratosphere remained at this temperature. Recently, however, a warm belt was discovered at 32 miles; the temperature here is a steady 170 degrees *above* zero. Higher up, it sharply decreases again.

The layer from 60 miles to 120 miles is called the ionosphere, of great importance to radio engineers because what little air exists there is electrically charged. This region is subdivided into several strata, each reflecting certain high-frequency radio waves back to earth. It is this charged air which makes it possible to send short-wave radio communications over long distances. The only radio waves which can penetrate this layer without being reflected back to earth are the ultra-short waves used for radar. Their ability to get through was proved conclusively in 1946, when the U.S. Army Signal Corps successfully made radar contact with the moon.

Also in the ionosphere we find the strange, pulsating glows of the aurora borealis and the aurora australis (these phenomena probably would be invisible to anyone passing through them on a flight to space). Because the auroras have traditionally been considered in the domain of the astronomers, members of this branch of science are, like radio experts, interested in the ionosphere.

Above the ionosphere, the air becomes so thin that it no longer serves any function. Scattered single particles of air (molecules and atoms) have been found here, and scientists have noted this fact by giving the area above the ionosphere a name of its own, the exosphere. But the particles are so rare that it is impossible to establish the limits of this layer. There are so few of them that at the 250-mile record altitude reached by the Army's "WAC Corporal" rocket, there is less air than in the best vacuum tube obtainable on earth. (See drawings. Reduced figure, right, shows "WAC Corporal's" course.)

It is at the boundary between the ionosphere and the exosphere that the upper limit of the atmosphere—and the lower limit of space—has been arbitrarily established by the two groups of scientists most interested: the astronomers and the rocket engineers. Their decision was based on the fact that both are concerned with the friction produced by air—the rocketmen because it creates a difficult barrier for rocket ships to cross; the astronomers because meteorites, which are in their scientific province, ignite upon striking fairly dense air. At 120 miles, air friction becomes, for the purposes of both groups, negligible. There space begins.



Tied to space station so he won't float away, spaceman wears radio and oxygen supply on back of pressurized suit, gets propulsion from portable rocket motor. Actual helmet will have dark glass to ward off dangerous ultraviolet rays; artist made it light to show face

CAN WE SURVIVE IN SPACE?

By Dr. HEINZ HABER

Department of Space Medicine, United States Air Force School of Aviation Medicine, Randolph Field, Texas

A multitude of problems will beset us, says this authority, but nothing we can't lick

ALL day long, the frail little man attending the forum had listened to the engineers and scientists discuss the conquest of the heavens with huge rocket ships and space stations. Now he had a question.

"Mr. Chairman," he said, "you fellows seem to have worked out all the details. You know how your rocket ships should be designed, you even have plans on paper for machines to reach the moon and other planets. But as an ordinary layman who knows little about these matters, I would like to ask this one question:

"Who is going to design the crew?"

The questioner had put his finger on the greatest difficulty facing the engineers, scientists and doctors in reaching space—man himself.

If the jet plane, guided missile or rocket ship is not perfect, the engineer can redesign the machine over and over until all the kinks have been ironed out. He has a great variety of materials and devices at his disposal. He may eventually succeed in developing a flawless machine. The same cannot be said for man. He is the most important link, and yet the weakest one, in any attempt to conquer space. And he cannot be redesigned.

True, man can adapt himself to extraordinary conditions—he manages to survive anywhere on the face of this globe. But what will happen to him if he ventures into the alien environment known as space—the void beyond the atmosphere?

There is no oxygen for breathing.

The lack of atmospheric pressure can cause his blood to boil.

Dangerous radiation (ultraviolet rays) from the sun hits him with full force and can broil him within minutes.

Atomic bullets, called cosmic rays, plow through his body.

He will be weightless, floating helplessly about, with no up or down.

In short, man was not made to survive in the "hostile territory of space." It becomes the problem of the engineers, therefore, to create a highly mobile, self-contained, "packaged" environment for space-faring man. In other words, he needs an airtight shell to produce and preserve earthly conditions as nearly as possible.

Man is extremely hard to please in his demands, but the engineer can lick the problem and supply the crew of a rocket ship or space station with all the necessities for survival. Neither rocket ship nor space station will have the snug comfort of Mother Earth, and flying through space will be a rough job that will call for healthy, tough and physically well-trained individuals. But it can be done.

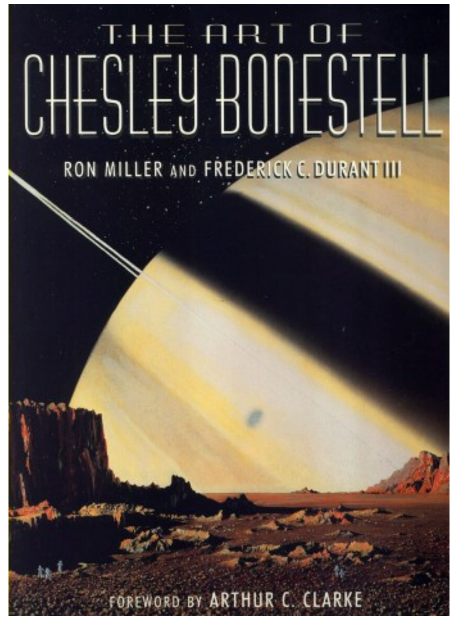
Some pessimists maintain *(Continued on page 65)*

DRAWINGS BY ROLF KLEP

The Chesley Bonestell Archives of Melvin H. Schuetz

www.bonestell.com

A former satellite controller in the U.S. Air Force and private industry, Melvin H. Schuetz has researched and collected publications from around the world containing Bonestell's art for more than four decades. His book, A Chesley Bonestell Space Art Chronology, is a unique reference bibliography containing detailed listings of over 750 publications which have included examples of Bonestell's space art.



Award winner Ron Miller & Black Cat Studios

Ron Miller, winner of the 2002 Hugo Award (World Science Fiction Society) for Best Related Work: The Art of Chesley Bonestell

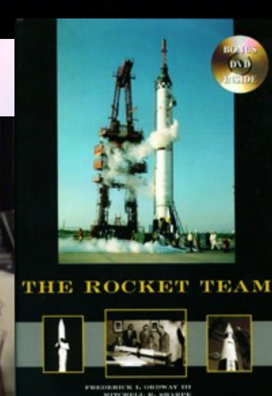
Dreams of Space, Books & Ephemera

Non-Fiction Children's Books about Space Flight from 1945 to 1975
http://dreamsofspace.blogspot.fr

Below: From John Sisson's Dreams of Space blog entry, this art is by Angelo Torres, from a 1961 non-fiction Classics Illustrated comic book, The World Around Us, Undersea Adventures #30.

Space scientist and well-known author of visionary books on spaceflight. Ordway was in charge of space systems information at the Marshall Space Flight Center from 1960 to 1963 and before that performed a similar function for the Army Ballistic Missile Agency. For many years he was a professor at the University of Alabama's School of Graduate Studies and Research. However, his greatest contribution has been to the popularization of space travel through dozens of books that he has authored or coauthored. He was also technical consultant to the film 2001: A Space Odyssey and owns a large collection of original paintings depicting astronautical themes. Ordway was educated at Harvard and completed several years of graduate study at the University of Paris and other universities in Europe.

www.cgpublishing.com



Frederick Ira Ordway III
Co-Author with Mitchell R. Sharpe of The Rocket Team

Can We Survive in Space?

CONTINUED FROM PAGE 35

that the crew members of a rocket ship wouldn't live to experience space, because they wouldn't even survive the tremendous stresses placed upon them during the ascent. The thrust of the operating rocket motors exerts strong forces upon the ship and its passengers. A motorist gets an inkling of one of these forces: if he steps on the accelerator, he is gently pressed against the back of the automobile seat. But this soft pressure in a car becomes a crushing force in a fast-rising rocket ship. As the space vehicle is whipped forward by the fiery jet of its escaping gases, the force increases in a slowly rising, irresistible surge. To the passenger, it will appear as though several men his own weight are standing on his chest. He will find it difficult to breathe. The fantastic acceleration will distend his features into a grotesque mask.

* * *

For short periods of time, similar stresses occur in present-day fighter aircraft when the pilot pulls out of a steep dive. For this reason, detailed studies have been made on the tolerance of humans under these conditions. In some experiments, men have been strapped into cockpitlike chairs which were then whirled around like a bucket on the end of a string. With such machines, the stresses encountered in modern aviation are being studied and measured. The results indicate that sturdy and healthy individuals will be able to withstand the rigors which the engineer deems inevitable for breaking free from the earth in a rocket ship. Probably the same medical requirements now applicable to Air Force or commercial pilots will be the yardstick used.

The stress of acceleration is not, of course, the only hazard man will encounter as he leaves the friendly atmosphere of the earth. A continuously flowing supply of breathing air is a necessity in the emptiness of space. Man can live without food or water for a considerable length of time. But without oxygen he can live only a few minutes. The crew of the space station must not be allowed to run low on oxygen at any time. Rocket ships will replenish the oxygen containers of the satellites at regular intervals.

Another problem, also tied up with the elementary fact that man cannot live without oxygen, is created by the existence of meteorites. They are the most important single danger to all space-travel projects.

Unfortunately, "empty" space beyond the atmosphere is by no means completely empty. In fact, you may call it a "no man's land" in which ultra-high-speed cosmic "bullets" fly about at random. Hundreds of millions of these "bullets" of various sizes enter the earth's atmosphere every day and often can be seen as meteors or shooting stars. When a cosmic pebble the size of a pea strikes the upper atmosphere, the air resistance heats it until it burns away. This can be seen hundreds of miles distant as a bright streak or flare. Such a meteor hurtling through space at 25 miles a second would puncture more than an inch of armor plate. Very small meteors, the size of large grains of sand, could riddle the thin walls of the space station, permitting the air to escape into space.

The reason for their penetrating powers is the extremely high speed with which these tiny objects move. At an altitude of 1,000 miles, the gravity of the earth pulls them in with a minimum speed of about six miles per second—21,600 miles per hour. Most meteors, however, would strike the earth (if they didn't almost invariably burn away first) much faster than this, even if the earth had no gravity at all. The earth moves around the sun at a rate of 18½ miles per second, or 66,600 miles per hour, while many of the meteors are moving in the opposite direction, and more rapidly. Head-on collisions between the earth and a meteorite raise the observed maximum speed, as calculated from photographs, to about 45 miles per second, or 162,000 miles per hour.

* * *

A radar warning system, unfortunately, would be useless in protecting the space station from meteors. If a meteor were large enough to be detected by the most sensitive radar, it would be large enough to destroy a complete compartment of the space station. And it probably wouldn't be seen until a split second before the collision; in that short interval, we could do nothing to prevent the collision, even if the space station were as mobile as a rocket ship.

That the chance of collision is great enough to cause alarm has been asserted repeatedly by Dr. Fred L. Whipple, of Harvard University's Department of Astronomy.

Dr. Whipple has made a careful study of that question and for the last 15 years has been photographing meteors and measuring the way in which they burn away by friction in the upper atmosphere. He has calculated that an artificial satellite or space station, such as is suggested on these pages, would be punctured by a meteorite about twice a month on the average.

This hazard is far too serious to be ignored in our engineering design. It is probable that the holes made by most meteors will be small enough so that the air would take some time to escape from a single section of the station, but these minutes of grace offer no real security. Even though bells and flashing lights might warn the occupants in time for them to put on oxygen masks before the air pressure became dangerously low, only the most steel-nerved space traveler could sleep calmly, knowing that at any moment the air might suddenly disappear from his quarters.

However, engineering can do something even about the meteoric menace. One device, suggested by Dr. Whipple, is called a "meteor bumper" and consists of a thin secondary wall placed an inch or so outside the main wall of the space station or rocket ship. Incoming meteors would shatter on the outer wall, leaving the inner wall intact. If properly constructed of heavy enough materials, the meteor bumper could reduce the hazard very considerably, stopping 99 out of 100 meteors.

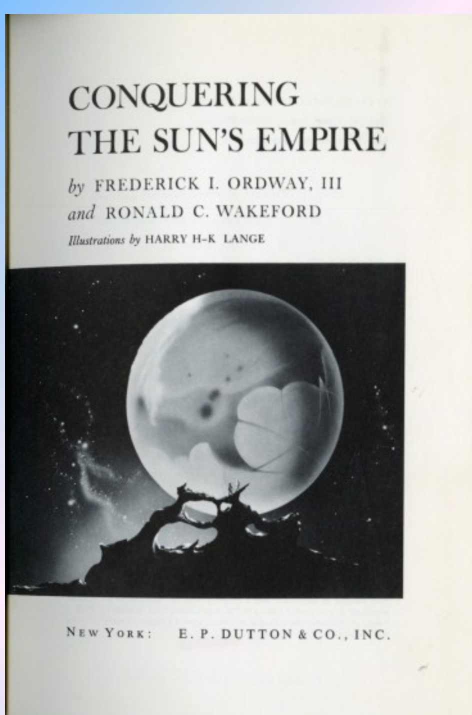
Added protection could be gained by having automatic plugging devices, similar in principle to the Air Force's self-sealing fuel tanks, between the two walls.

* * *

For the space station, Dr. Wernher von Braun, Technical Director of the Army Ordnance Guided Missiles Development Group at Huntsville, Alabama, suggests another method. Each compartment would have a small pressure gauge which would automatically close the doors in the section the moment the pressure dropped as a result of a meteor hit. At the same time, it would automatically start an emergency air blower which would build up the air pressure in the damaged section. Dr. von Braun believes that sufficient time might be bought in this way for the occupants to climb into their space suits. To find the small hole, he also suggests that a harmless colored gas be pumped into the section. This gas would immediately drift toward the opening, which could then be plugged.

But even with these safety measures, there remains a probability that once every few years a relatively large meteor will

"It is filled with truly beautiful space art by Harry H-K Lange. Mr. Lange was involved with some of the concept drawings for the film 2001 [A Space Odyssey], as well as illustrating [a] von Braun book about the history of rocketry." Source: John Sisson's Dreams of Space blog entry of June 18, 2012. This 1963 book is co-authored by Frederick Ira Ordway III.


CONQUERING THE SUN'S EMPIRE

by FREDERICK I. ORDWAY, III
and RONALD C. WAKEFORD

Illustrations by HARRY H-K LANGE

NEW YORK: E. P. DUTTON & CO., INC.


Explorers on Callisto, the second largest moon


Explorers on Miranda viewing the banded atmosphere of Uranus


Astronaut descending from his spaceship onto the surface of the Moon

Above are three more images from John Sisson's Dreams of Space blog entry for "Conquering the Sun's Empire (1963)", a book by Frederick I. Ordway III and Ronald C. Wakeford, with illustrations by Harry H-K Lange.

"This is… a book for high school students about man's exploration of the solar system."

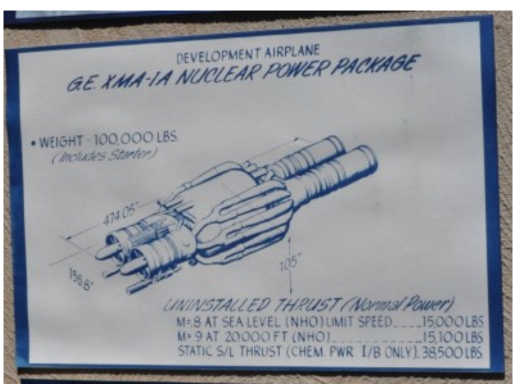
Aerospace Cyanotype Blueprints

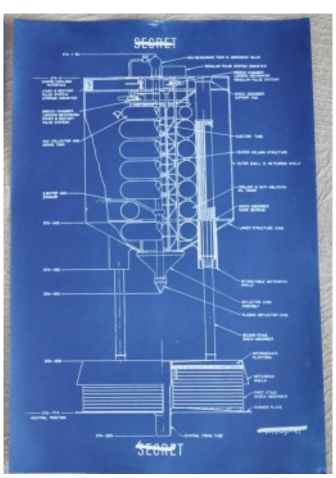
Before digital printing, before the photocopier, diagrams were reproduced via the "blueprinting" process where specially prepared paper was overlaid with a translucent hand-drawn original and exposed to either sunlight or special lamps. The "cyanotype blueprint" has long since fallen out of favor for engineering diagram reproduction, but there's no denying the aesthetic appeal.

Now available are a series of hand-made blueprints, produced in the original fashion using vintage aerospace diagrams. The perfect art for any aerospace enthusiast.

http://www.up-ship.com/cyan/cyan.htm

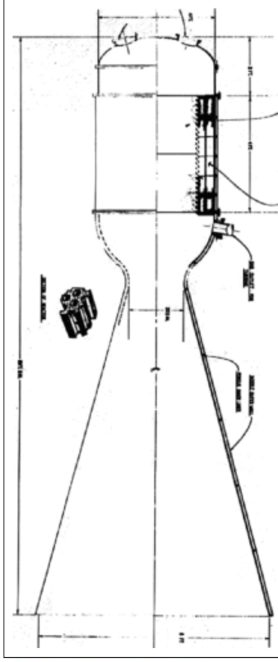
Some examples:





APR Corner, Mini Edition: Early Nuclear Rocket

By Scott Lowther



A North American Aviation concept for a nuclear thermal rocket: 1947. For use in 10,000 n.m. range ICBMs or SSTO vehicles. See APR issue V2N2 for more www.aerospaceprojectsreview.com

smash through both walls of the space station. What would happen to the crew in that compartment?

The air would whistle out, and there would be a rapid drop in pressure. As a result, the crew would be "explosively decompressed." Even the lungful of air the men had inhaled with their last breath would be torn from their chests. They would have exactly 15 seconds left to restore their oxygen supply, before losing consciousness; without the oxygen they would die in a few minutes.

These prospects sound grim, but things are no different today in our modern rocket-driven airplanes. Last fall, the Navy's Douglas Skyrocket—actually a man-carrying rocket craft—rose to an altitude where the air was so thin that breathing became impossible. In this respect the pilot of the Skyrocket was actually in space. He wore a pressurized space suit even though he sat in a pressurized cockpit, for he couldn't risk one of his canopy panels being torn out. If he had lost his cabin air, he would still have had enough oxygen in his airtight suit to have escaped space death.

In the early days of space exploration, it may be found safest to wear a pressure suit even in the pressurized cabin of the rocket ship. But because of the protective devices inside the space station, pressure suits might be worn there only in times of emergency. A slow leak would not be considered serious, for the crew would have plenty of time to retreat into an adjacent compartment and seal off the damaged section until repaired.

* * *

Pressure suits for use by the crew outside the space station can be made of several layers of rubberized nylon topped by a sturdy metal helmet. The helmet's window would have to be made with a darkened piece of transparent material to ward off the sun's excessive ultraviolet rays. Of course, the crew members will carry their own oxygen, and the suits will be equipped with a small air-conditioning unit for removing the exhaled stale gases.

Humidity control will also be very important. The humidity in the suit might be compared to that endured in a three-hour stay in a telephone booth on a summer day, with a temperature of 90 degrees Fahrenheit and a relative humidity of 95 per cent.

For a brief stay in space, the removal of carbon dioxide and water vapor and the replenishing of oxygen will be sufficient. But the space station must be fully air-conditioned, because a proper atmosphere must be permanently maintained.

The skin of the space station, the paint, the cargo, the complex machinery which is in constant operation and even the bodies of the crew all give off fumes. On the ground we hardly notice the smell in a machine shop, for example, because it is dissipated by air currents. However, in the space station such vapors might in time poison the occupants, if they were allowed to accumulate. Even smoking will probably be strictly rationed, partly to save oxygen and partly to avoid overloading the capacity of the air-conditioning unit.

In venturing into space, man abandons the powerful shield or filter of the atmosphere which protects him on earth from the hazards of the little-known effects of cosmic rays. These atomic bullets—which, like the meteors, crisscross space at enormous speeds—are one of the great mysteries of the region beyond our atmosphere. Scientists know they exist and believe they may be dangerous, but little other information on them has come to light.

Cosmic rays are potentially dangerous because they are related to some of the types of rays produced in atomic explosions and in the manufacture of the A-bomb. Civil defense has made the public conscious of the term "radiation sickness." Will exposure in space cause radiation sickness?

We have no clear-cut answer to this question. Cosmic rays are so powerful that they cannot be reproduced artificially in the laboratory. But, although we do not know where they come from, we do know that they are extremely rare. We can conclude, therefore, that short trips through the thin rain of cosmic rays will almost certainly be harmless affairs. A round-the-moon trip can be made without getting radiation sickness. At this time practically no information is available as to the possible ill effects of extended cosmic-ray exposure. But if it should be found that man can absorb only so much cosmic radiation with safety, frequent rotation of the space station personnel will be the answer.

Of course, long before man ventures into space, animals will be sent up in small rocket ships for the study of radiation effects over extended periods of time. A sheep, a rooster and a duck were the first living beings to take to the air in a balloon, more than 150 years ago. And it seems that more such honors are in store for the animal kingdom. Unfortunately, however, these dumb animals will be unable to communicate their experiences. So, in the final analysis, the exploration of space must await the arrival of man.

* * *

It will be, needless to say, a strange experience. And one of its strangest aspects will be the absence of gravity (except within the space station, which will provide its own "synthetic gravity" by spinning slowly to produce centrifugal force). The result of the lack of gravitational pull will be weightlessness—and there can be no doubt that weightlessness will be the most unearthly and unforgettable experience shared by those who venture beyond the earth's atmosphere. Space and weightlessness will become synonymous, like desert and thirst, or arctic and cold.

The consequences of weightlessness are being discussed in many circles of medical science, and the opinions expressed cover a wide range of possibilities. Some believe that weightlessness will be entirely harmless; others have gone so far as to predict that man can survive only a few minutes without gravity. This latter point of view, in the opinion of top experts, is almost certainly wrong.

In the first place, blood circulation will be affected only slightly. The heart pumps the blood through the body whether it has weight or not. Secondly, eating does not require the help of gravity. We can even eat "upward," while hanging head downward from a bar. Neither will the digestion be influenced.

* * *

While the machinery of the body will go on operating in an orderly fashion even if it is weightless, man will possibly encounter trouble when he attempts to go about his daily routine. Weightless man may well find himself in this position:

Imagine a muscular weight lifter taking a good grip on what he thinks is a solid 300-pound weight, but is actually a much lighter contraption made of wood. His anticipation is utterly deceived, and the ill-adjusted strength he applies, to his great surprise, throws the fake weight violently upward.

Space-faring man will consistently experience much the same thing: he will find that his co-ordination, based on a lifelong experience with gravity, suddenly fails him in this new environment. A simple movement on earth, such as rising from his chair, will, in space, jerk him across the cabin toward the opposite wall. The co-ordination of the body, which is so automatic here on earth that we take it for granted, will have to be acquired all over again.

Since the customary effects of gravity are absent, there is no "up" or "down"—a factor certain to prove confusing. Normally, we rely to a great extent on gravity for orientation. But in a rocket ship, all orientation will depend on the eyes. It probably can be acquired, but until it has been learned, there exists the possibility of "space sickness," which will reduce efficiency even if it does not completely incapacitate the crew.

Not only the men will float around aimlessly in the weightlessness of a coasting rocket ship—objects will do the same, and this will cause trouble if careful thought is not given to the design beforehand.

In space, we must use other forces to substitute for gravity. Every metal object must be made of steel, or at least have a steel strip inlaid somewhere on it. Such tools can be kept in place with magnets, along the lines of the magnetic knife board in use in many of today's kitchens. Where magnetism cannot do the job, as with papers, friction will have to substitute for gravity—the clip-board is an everyday example of such a device.

As for eating utensils, the function of the knife and fork will remain the same. The knife still cuts and the fork utilizes friction to hold food after it has been speared. The spoon, however, is useless aboard a rocket ship (and so is the fork when used like a spoon), so the well-planned table in space will include some offspring of the sugar tongs, something which will hold food by friction.

Liquids will be especially annoying; any liquid from milk to Burgundy is likely to imitate what any bottled heavy sauce does on the ground. If you tilt a bottle in space nothing will come out, for, since the liquid does not weigh anything, there is no reason for it to pour. But when you shake the bottle, all the contents will come out in one splash. The solution to that particular problem is a very old invention: the drinking straw, which does not rely on gravity but on air pressure. Another method: plastic bottles, which, when squeezed, eject liquid.

Cooking aboard the space station will not be too difficult, because the satellite enjoys synthetic gravity. However, in rocket ships it will be quite different from the same process on the ground. Open pots or pans are useless, for boiling water will simply erupt from an open pot because of the steam bubbles which form at the bottom. Likewise, the first explosive sizzle of a steak's fat will send the meat floating across the cabin. Only closed cooking pots can be used and the ideal broiler is the so-called electronic range which cooks by short wave. (Naturally, if the crew members of the rocket ship are wearing pressure suits, they will have to open the visors of their helmets to eat.)

In long rocket-ship trips from the space station to other planets, seasoned space travelers may enjoy sleeping literally on an air cushion, just floating in air, possibly with a string tied to their wrists or ankles so that the reaction of their breathing will not "float" them away.

* * *

So far, we don't know whether the familiar pressure of a bed against the body is necessary for falling asleep. If it is, it can be "faked" during the weightless state by having a set of rubber straps force the body against a board or other flat surface. Beginners, however, will have to sleep in special bunks. These will look like six-foot lengths of pipe, upholstered inside and equipped with wire mesh covers at both ends. These wire mesh covers—the "wire" would probably be nylon string and the mesh widely spaced—would keep the sleeper inside his "bed." Without them, he might push himself out of it by unconscious movements or even be sucked over to the outlet end of the air-conditioning system.

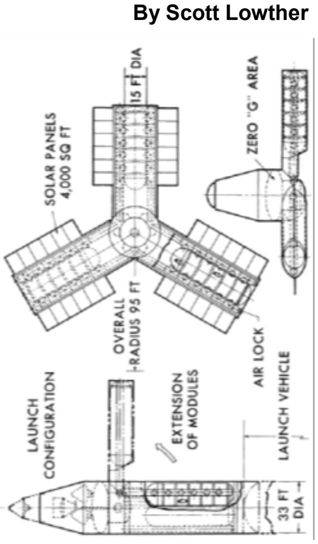
For most of us, weightlessness will hardly be an agreeable and welcome feeling, and learning to live with it may prove a painful lesson. However, man has an astonishing ability to adjust himself to extreme conditions. A few individuals may even get to enjoy weightlessness, after a fashion. The crew members will probably be able to master its intricacies and go about their daily chores with ease.

We can be reasonably certain that man will be able to survive in space because we have sufficient knowledge of what will happen to the rocket ship or space station and to man himself. We can plan intelligently for his survival. Unlike the earth's early explorers, the pioneers of space know pretty well what they are headed for, and they know that they will be equipped adequately.

The conquest of space hinges on man's survival in space. And the crews of rocket ships and space stations, while they can never be completely protected against hazards such as meteors, will probably be safer than pedestrians crossing a busy street at a rush hour. THE END

APR Corner, Mini Edition: Radial Module Space Station

By Scott Lowther

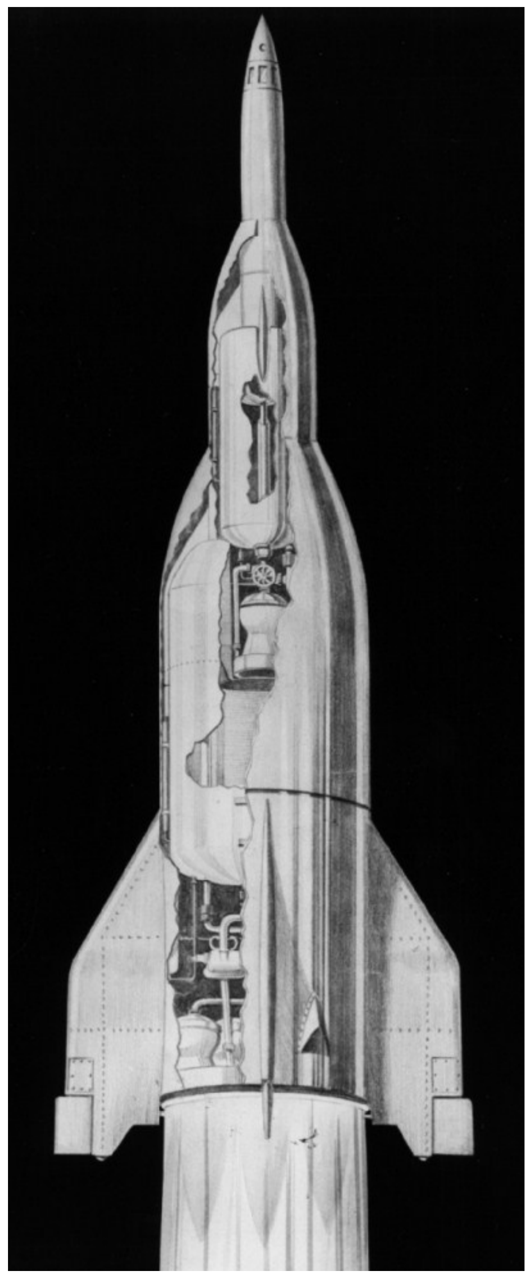


NASA concept for artificial gravity space station, ca. 1963. This would be launched by a single Saturn V. See APR issue V1N6 for more www.aerospaceprojectsreview.com

APR Corner, Mini Edition: A-9/10/11

By Scott Lowther

Werner von Braun had plans for more advanced versions of the A-4 ("V-2") rocket during WWII. The A-4b, for instance, was to have stubby wings that would increase range via gliding. The A-9 was to be the second stage of an ICBM, with the all-new larger A-10 1st stage. After the war, von Braun claimed to US Army interrogators that he had even further plans… the A-11 would go under the A-9/10, putting the A-9 into orbit; the A-12 would go under the A-11 and orbit an A-10 modified into a reusable shuttle. While there is virtually no evidence of these designs having been any more than vague notions during wartime, in 1946 at Ft. Bliss von Braun directed the artist Gerd de Beek (an illustrator at Peenemunde) to create a cutaway painting of the A-11. A few particulars for the A-11 and A-12 were produced, though apparently no illustration of the A-12. The numbers given for the A-12 turn out to be virtually identical to those of the *Collier's* Ferry Rocket, providing a heritage from the V-2 to the Ferry Rocket.



More information on A-4 derivatives including the A-8, A-9, A-10, A-11 and A-12 can be found in issue V5N6 of *Aerospace Projects Review*. www.aerospaceprojectsreview.com

Mars, at its closest 35,000,000 miles from the earth, as seen from its outer moon Deimos, where man could land before going on to the planet

Who Owns the Universe?

By OSCAR SCHACHTER

Deputy Director, Legal Department, United Nations

The approaching age of space travel poses legal problems that lawyers already are grappling with. The freedom-of-the-seas principle may solve some of them

WE HAVE all heard about attempts to sell real estate on the moon and have laughed at the poor suckers who bit. Indeed, to say that someone wants the moon means simply that he wants the impossible. But now that scientists have shown that man can conquer space and that new worlds lie within his reach, the question of "owning" the moon and the planets no longer seems to be so much of a joke. Today, the question is not at all farfetched and, in fact, it may well have important consequences for all of us.

Of course, the real issue is not whether private individuals may sell real estate on the moon or go into business outside of the earth. The serious question, like so many others today, concerns national governments and their respective rights and powers. Will these governments claim "ownership" (or, more correctly, sovereignty) of the moon and other celestial bodies, just as today claims are being made to the barren wastes of the antarctic? Will there be national rivalry to plant the Stars and Stripes, the Union Jack and the Hammer and Sickle far off in space, so that the governments can then assert exclusive control and keep others away?

And what of rocket ships and space stations? What rules will govern them and, most important, will they be free to move about high above peaceful nations, laden with weapons of mass destruction? In this time of international tension, it may not be too soon to think about these questions.

Where can one find principles and precedents to answer these problems? Interestingly enough, we have to go back four centuries, to the great age of exploration and conquests, when Columbus, Magellan, Vasco da Gama and the Cabots found and claimed new worlds for their royal sovereigns. It was these colorful adventurers, hunting for treasure and glory, who set the scene for the development of new legal principles— indeed, of the whole new system of international law that was to govern the relations between independent nations for centuries thereafter. The reason for this was that the discovery of these new territories immediately presented political and legal issues.

The great maritime powers of that day, Spain and Portugal, had to find a method of settling their claims to avoid war. With the advent of British sea power, further adjustments had to be made. There was the obvious problem of deciding who was to exercise sovereignty over the new areas. (The lawyers referred to these regions as *"terra nullius,"* that is, land which belonged to no one.) Was it enough that the navigators made the initial discovery and then sailed away after planting the royal emblem? Or was it necessary that there be an occupation, at least a small settlement, in order to acquire dominion over the newly found region? And, finally, could the seas themselves be claimed as national territory?

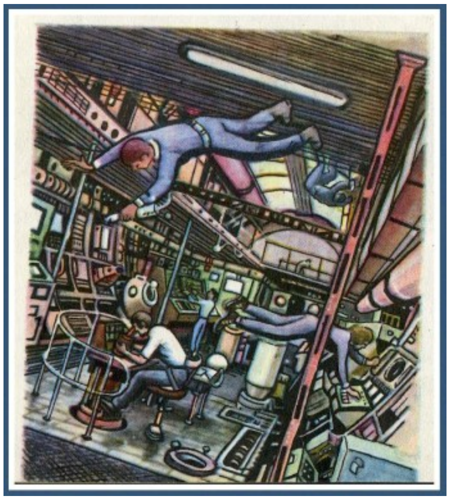
At first, it was thought that these questions could be settled through the authority of the Pope. Almost immediately after Columbus' discovery, the famous Papal Bull of 1493 was issued, dividing the world between Spain and Portugal by a meridian line running a hundred leagues west of the Azores, through both poles. What *(Continued on page 70)*

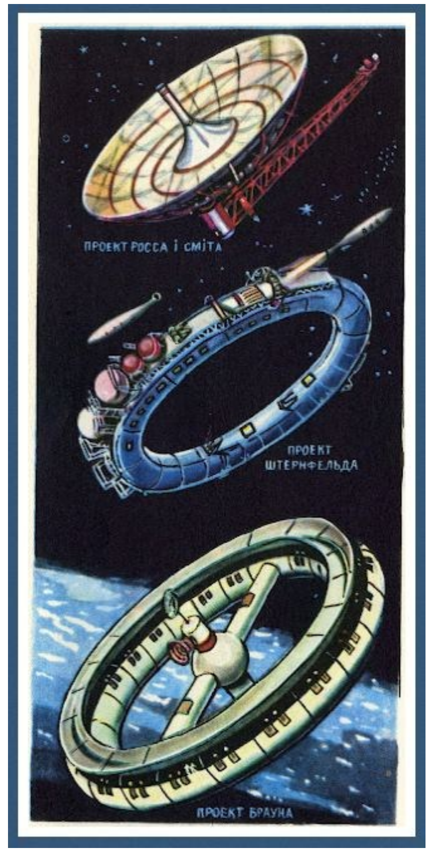
PAINTING BY CHESLEY BONESTELL

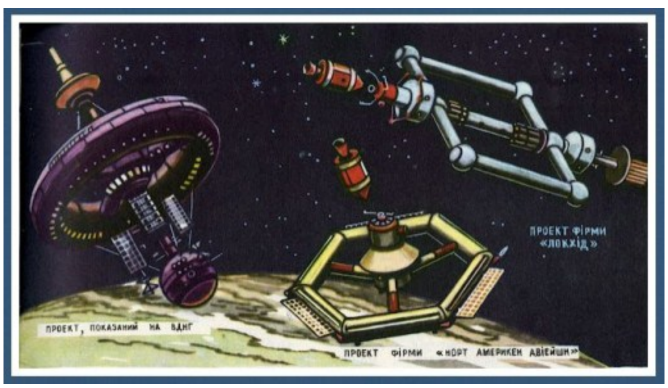
Dreams of Space - Books and Ephemera

Non-Fiction Children's Books about Space Flight from 1945 to 1975

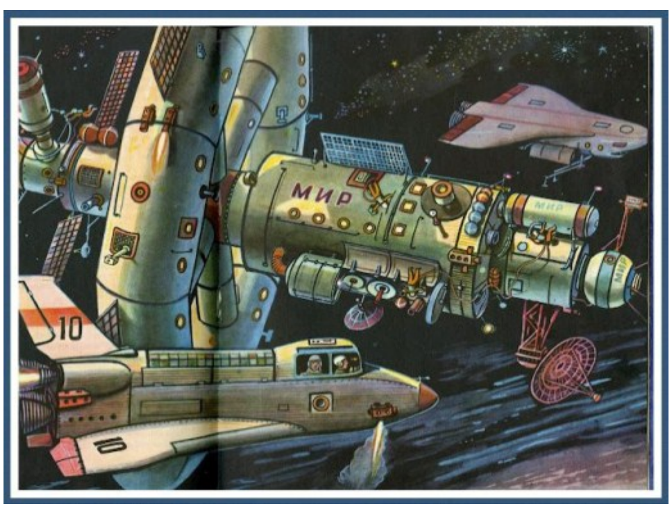
http://dreamsofspace.blogspot.fr

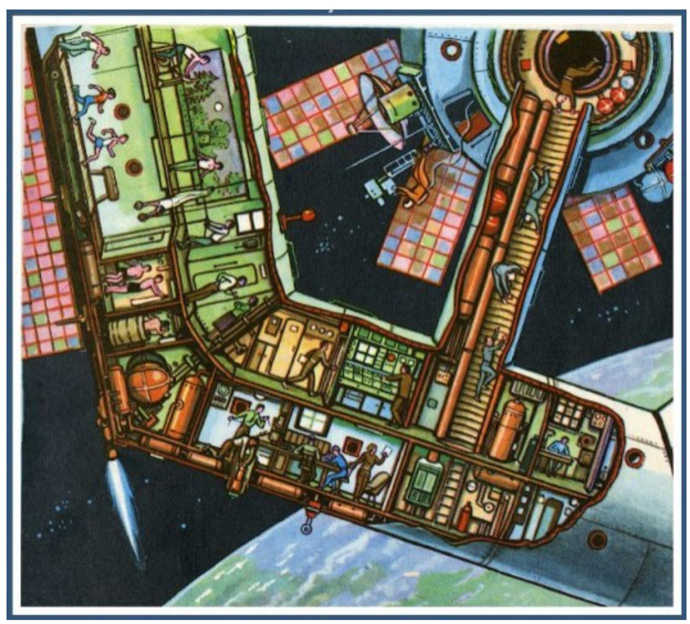






These are a few of the images from John Sisson's Dreams of Space article about this1975 Russian (1979 Ukrainian) book, "Home on Orbit."

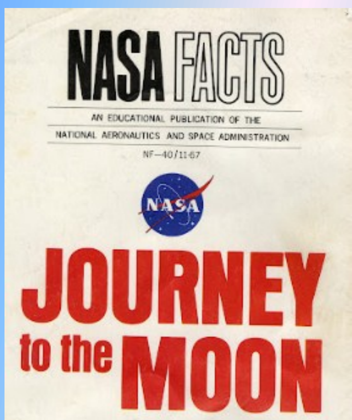




The blog entry of July 20, 2012 from John Sisson's Dreams of Space presents:

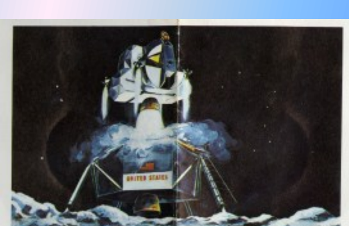
Journey to the Moon
NASA Facts 40-11/67 (1967)

"The paintings are beautiful [examples] of what they expected to see."



9 One astronaut remains in lunar orbit while two land on the moon in the lunar module.

10 The two astronauts explore the moon, obtain samples and place instruments.



11 With descent stage as a launch pad, the ascent stage fires for liftoff.

Who Owns the Universe?

CONTINUED FROM PAGE 36

is probably most significant about this papal bull (and others like it) was that it introduced the notion of law to the problem of new territories. It was based on the assumption that sovereignty was not just a matter of naked power or, as it has been called, of the "divine right of grab"; at least there had to be a legal basis.

However, the papal bull did not settle the actual problem. England for one, as a Protestant country, did not accept it; moreover, English freebooters like Sir Francis Drake and Sir John Hawkins soon made a mockery of Spanish claims to dominion over the seas. With the victory over the Armada, all claims to exclusive ownership of the high seas by Spain were effectively ended. The significant result was the development of the principle of freedom of the seas, a fundamental feature of international law, and one which has contributed greatly to the peace and economic development of the world.

In regard to the land, as in the case of the sea, the decree of the Pope was not a final settlement, but only the beginning of the development of rules of law. Both Spain and Portugal were soon obliged to justify their claims by legal principles. It was then that new rules emerged which were to decide what countries were to govern the new territories.

What were these rules? Perhaps the most important was that the mere discovery of new territory was not considered sufficient to confer sovereignty. Even extended exploration was not enough; nor did the giving of names to portions of the lands or waterways make any difference. It was, however, agreed that if a country effectively occupied new territory, through settlement it acquired sovereignty. Thus Columbus felt obliged to leave some of his crew on the island of Hispaniola (Haiti) to justify legally the Spanish claims.

* * *

But it is important to note that settlement was not always essential. In many cases, claims rested merely on certain symbolic acts of possession. The French and Portuguese would erect crosses or monuments bearing the royal arms. The Spanish and English used more elaborate ceremonials, usually a whole ritual, to denote the formal taking of possession. For example, the English sometimes used a "turf and twig" ceremony, taking from the land a clod of earth and a twig as tokens of acquiring ownership. The Russians also employed symbolic acts, such as burying copper plates bearing their coat of arms in the Aleutian Islands and the Alaskan coast. These various rituals were generally considered effective, though it is by no means certain that they would be accepted today.

In recent years there has been further development. The emphasis has shifted from the taking of physical possession and settlement to displaying the authority of government in a practical way. The whole problem is presented sharply today in connection with claims to the antarctic region. This great area has been claimed by a number of nations on the basis of exploration and display of governmental authority. But so far none of these claims has been accepted and the controversy remains unresolved.

The dispute over the antarctic shows how the principles of law developed in the period of the discovery and exploration of America have their effects today. Moreover, the controversy foreshadows the conflict that may arise when the first rocket ships reach the moon and other celestial bodies.

Governments will, of course, tend to think and act in terms of their own particular interest; they will normally use past practice to further their special claims. If this pattern is followed, we may expect to see that the first landings on the moon will involve all sorts of acts intended to support claims of sovereignty. Obviously, the flag will be planted and, very likely, names will be given to places on the moon (though astronomers have already named the larger lunar features). We might then be reading of lunar "Washingtons" and "New Yorks," perhaps of King George mountains and Stalin craters.

In place of the old ceremonials with crosses and coats of arms, scientific instruments might be left behind, and these might be regarded as having symbolic as well as practical value. Finally, there might be attempts by governments to exercise control, perhaps even to issue licenses, and to claim the right to exclude those who are not licensed. All of this would be the old story of territorial rivalry—but this time extended into the heavens themselves.

We may well ask whether this is the only way governments can deal with the problem. Would it not be possible to by-pass the whole problem of national sovereignty in outer space?

The answer to this might be found in the analogy with the system governing the high seas. We have already seen that at one time governments maintained that the open seas as well as the land belonged to them. These were not just theoretical claims; they were enforced by men-of-war. Passage was often prohibited and tolls were levied. It was not until the time of Queen Elizabeth I that this system was challenged.

When the Spanish ambassador lodged a protest against Francis Drake's voyage to the Pacific in 1577, Elizabeth rejected the protest, declaring that the sea, like the air, was common to all mankind and that no nation could have title to it. The Dutch (like the English, a rising maritime and commercial power) also flouted Spanish and Portuguese claims. Their jurists, including Grotius, the father of international law, argued that the sea was common property and that all peoples were to use it. Gradually this idea prevailed.

Why not extend the same principle, now applicable to the open seas, to outer space and the celestial bodies? These areas would then be considered as belonging to all mankind, and no nation would have the right to acquire any part of them, any more than a nation now has the right to acquire parts of the open sea. The whole idea of national sovereignty outside of the earth would thus be eliminated.

But it might be asked whether this would not result in a state of anarchy, with no rules or restraints whatsoever. The simple answer to this might again be drawn from the analogy with the high seas. Obviously, the open sea is not in a condition of lawlessness; it is, in fact, subject to law, although not to the authority of any single nation.

Similarly, laws would have to be developed to apply to outer space. Certainly a principal object of such laws would be to encourage scientific research and investigation. Thus, there would be the idea of free and equal use rather than exclusive use. Space travel, like navigation on the seas, would be permitted to everyone, no matter what country he came from or under what flag he traveled. In general, interference with such travel would be prohibited and governments would not have the right to appropriate portions of space.

* * *

There might have to be exceptions to the general principle that outer space is completely free and cannot be appropriated. Perhaps governments might be given the right to own and maintain scientific installations, just as today countries are permitted to have lightships and weather stations permanently installed on the open seas. Suppose also that valuable mineral deposits are found on the moon or a planet—would there not have to be a rule permitting countries to exploit these resources when they have discovered and developed them? True, this would be a departure from the idea of free and equal use, but on the other hand it would be quixotic to declare that valuable minerals found and developed by one country should be available to anyone and everyone.

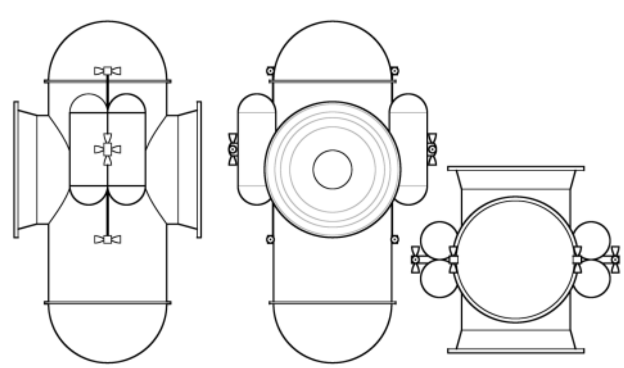
A more immediate problem is presented by the rocket ship itself. When we consider the possible uses of such ships, all sorts of questions arise. Will they be permitted to move about, free from the authority of any particular country and free of any other restraints? One might, for instance, envisage a space station high above the earth equipped to send radio or television signals to the earth. Would that satellite, therefore, be free of all the regulations, both international and national, which safeguard the public interest in this field? And if control is to be exercised, how should it be made compatible with the principle of freedom of outer space which we have urged?

The best way to meet this problem, it

APR Corner, Mini Edition: GD Space Taxi

By Scott Lowther

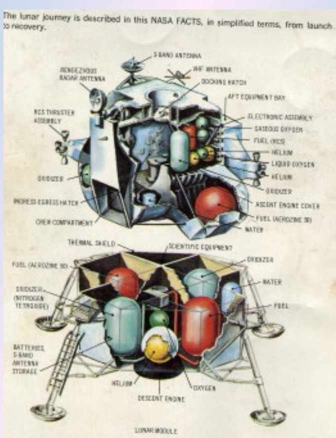
A 1964 General Dynamics "space taxi," similar to the space taxi illustrated more than 10 years earlier in the *Collier's* series. It was a minimal spaceship that would allow crew to transfer between spacecraft without docking the ships or donning spacesuits. Two versions designed… a -man taxi ~9.3 ft tall and a 2-man craft ~11.4 ft tall.



We continue with this blog entry of July 20, 2012 from John Sisson's Dreams of Space:

Journey to the Moon
NASA Facts 40-11/67 (1967)

"On the backside of the [poster] is an enormous painting which I could only scan in pieces. Whether you were alive to see it or are only looking back, it was an awesome moment in the history of the human race and sets us all to dream of what might be possible."



seems to me, is to begin with the idea that each space craft must bear the flag of a particular country; that is, it must have a nationality (perhaps, as an exception, there might be some space craft which could belong to an international organization). If a ship tried to evade this rule, it would be in the same position as a pirate of old and it would be subject to seizure by any government able to lay hands on it.

By requiring that each space craft have a nationality and a flag, it becomes possible to supervise them and control them. They then become subject to the discipline and the laws of the flag-state. If they failed to comply with those rules, they would become subject to penalties. At the same time, the government whose flag they fly would have to guarantee the proper use of the craft. The flag would also protect them against any abuses from other governments.

Since the craft would be mainly subject to national rules, it would be desirable that these have common features. By way of illustration, there would have to be agreement regarding signals for radio communications and similar matters. For the most part, however, the regulation would be left to the government whose flag the craft bears. That government would, in the first place, decide whether the craft was entitled to bear its flag. It would also determine the authority which the captain would exercise; it would provide for the safety of the personnel aboard and it would define and punish criminal acts. To a large extent these rules would be similar to those applicable on the high seas and many questions could be decided simply by referring to the law governing vessels at sea.

Let us return to the example of the space station engaged in broadcasting radio or television programs. In the first instance, the regulation of that station would be carried out by the country to which it belongs. Thus, an American television station operating in outer space presumably would be subject to the authority of the Federal Communications Commission. Perhaps new regulations would have to be devised to meet engineering problems which might arise; but, in any case, it would be clear that a station would not be free to evade control by its own government.

* * *

A much more difficult problem would be presented by a rocket ship or space station devoted to military purposes. In this case, the analogy with the high seas may be questionable. The high seas, as we well know, may become a theater of war and, generally speaking, there is no prohibition against belligerent vessels utilizing the open seas for warfare. However, when one conceives of a rocket ship or space station operating far above the earth with bombs of mass destruction, there can be little doubt that the potential danger to mankind would far exceed that which could be caused by a ship of war on the high seas.

This factor may lead to a demand that the use of outer space for military purposes be outlawed. But whether space craft as implements of warfare should be considered separate from other questions of security and disarmament might well be a controversial question in this period of international tension.

Although we have been talking about outer space, we have said nothing about where outer space begins; or to put it in another way, how far up does the territory of a country extend?

Now, this is not a brand-new question. In ancient Roman law, the landowner was considered to own the space above the land upward "to the heavens." But the idea of a private landowner owning all the space above his land has long been abandoned. Today, a man no more owns the air above his land than a man with a house on the seashore owns all the sea in front of his house. However, in contrast, it is well established that a nation does own the space above its territory. This principle obviously has considerable importance in regard to aviation. Thus, when governments entered into treaties relating to aviation they declared that "every power has complete and exclusive sovereignty over the airspace above its territory." This is accepted in international law.

Now, what does the term "airspace" mean in this sense? Does the term "air" extend only to the upper atmospheric regions? Should it be defined in terms of the composition of the gases or their density? So far there has been no authoritative answer to this question. The reasonable answer, it would seem, is to consider that the term is used in aviation treaties and therefore it is presumably intended to refer to the part of the atmosphere which contains enough air to allow aircraft (including balloons) to fly. Up to now balloons have gone as high as 21 miles, but it is estimated that air sufficient for flight extends about 60 miles above the earth. Beyond that there is no airspace so far as aircraft are concerned.

Whatever may be the precise boundary of the airspace, it is clear that when we go beyond it we are legally in a no man's world. The whole idea of national territory above the "airspace" would be based on a theoretical and fanciful notion, without any practical application.

* * *

It has been proposed that the upper territory be limited in terms of a country's power to exercise effective control. Presumably, this means that if a state can "control" *(i.e.,* stop) the flight of another nation's rocket at a certain distance, then territorial sovereignty should be limited to that distance. This position has been put forward by a distinguished authority, Mr. John C. Cooper, the director of the Institute of International Air Law. He has proposed "that at any particular time, the territory of each state extends upward into space as far as the then scientific progress of any state in the international community permits such state to control space above it."

It is interesting to note the resemblance between this approach and the old three-mile rule which has fixed the area of a country out into the ocean. This three-mile rule was also based on the idea of effective control—in particular, on the range of shore artillery batteries. At the end of the eighteenth century, these batteries had a range of about three miles, and therefore it was considered that that portion of the sea was within the control of the state.

Although the principle of effective control has been important in international law, one wonders whether it should be applied to this new problem of space travel. It would seem to mean that whenever a country could prevent or interfere with the movement of a rocket ship or space station it would have the legal right to do so. Would this not, in effect, simply be a rule that "might makes right"? And would it not place rocket ships and space stations at the mercy of those national states which would be able to interfere with their free passage?

There certainly does not appear to be any compelling reason in law or principle to carry national sovereignty this far. Indeed, any attempt to extend national territory higher than the airspace is bound to involve difficulties. Why not, then, fix the limit at the upper boundary of the airspace and no higher?

Beyond the airspace, as already noted, we would apply a system similar to that followed on the high seas; outer space and the celestial bodies would be the common property of all mankind, and no nation would be permitted to exercise domination over any part of it. A legal order would be developed on the principle of free and equal use, with the object of furthering scientific research and investigation. It seems to me that a development of this kind would dramatically emphasize the common heritage of humanity and that it might serve, perhaps significantly, to strengthen the sense of international community which is so vital to the development of a peaceful and secure world order.

THE END

...SPACE QUIZ

The fascinating aspects of man's study of space are—like space itself—infinite. Naturally, not every one of them could be incorporated in this symposium. However, some of the most intriguing questions which arose during the preparation of this issue, and the answers provided by the scientists who participated in it, are listed below

Q. ***Is interplanetary travel possible?***

VON BRAUN: Certainly, once we have a station in space that would enable us to take off refueled and unimpeded by the earth's atmosphere. Although Venus is the closest planet (26,000,000 miles when it swings toward the earth), the easiest interplanetary trip would probably be to Mars (35,000,000 miles), since either of its two moons is close enough to serve as a space station for the return voyage. To land on Venus, we would have to establish a temporary space station around it. Traveling at the most economical speed, a rocket could make the one-way trip to Mars in 258 days, or to Venus in 146 days.

Q. ***Have any living creatures already been rocketed into space?***

LEY: Yes. It has been announced that certain plant seeds and specimens of the fruit fly (the species *Drosophila melanogaster,* widely used in experiments in genetics) were sent up in V-2 rockets a few years ago. They made the trip unharmed. It seems reasonable to assume that larger creatures have been rocketed past the atmosphere since then.

Q. ***How large can we expect the meteorites to be which will endanger space travel?***

WHIPPLE: They will vary in size from pellets much smaller than a grain of sand (the tiniest of these are called cosmic dust) to monstrous—and, fortunately, rare—affairs that might be termed "flying mountains." The largest meteorite on exhibit anywhere in the world is the Ahnighito, found in Greenland, which is on display at New York's Hayden Planetarium and weighs at least 35 tons. But there is one embedded in the ground at a place called Hoba West, near Grootfontein, South-West Africa, estimated by some to weigh as much as 60 tons. Cosmic dust will not pose a real threat in space, but it will be a nuisance. For although it will not be able to puncture the walls of a space station or rocket ship, it will slowly sandblast all windows continuously exposed, making them more and more difficult to see through. The solution might be transparent plastic window coverings, which could be discarded when rendered useless by the tiny meteorites.

Q. ***What are some of the unsolved hazards that man will encounter in space?***

HABER: Granting that scientists have found a workable solution for the menace of meteorites, the greatest remaining hazard is that of the mysterious cosmic rays—nuclear bullets like those released by the atomic bomb, which streak unpredictably through space. To bar them entirely from space craft would require an extremely thick wall of lead or an armor of nickel-steel at least two inches thick. Either of these would be prohibitively heavy. Fortunately, although no one knows how dangerous cosmic rays are, many experts are quite optimistic. Another unsolved hazard is a psychological one: men cooped up in small rocket ships, on long trips through space during which there is little to keep them occupied, will suffer from such severe boredom that it may become a very important factor in space travel. There are lesser problems, too, of course, but in all probability most of the hazards of space will be solved by the time construction of the first space station is completed.

Q. ***Since some of the planets have no atmosphere, is it possible that someday we may lose ours?***

KAPLAN: Not unless two very unlikely events occur: (a) if the earth inexplicably loses much of its weight (and, therefore, much of its gravity); or (b) if we move closer to the sun. The more heat the sun pours into the molecules of air that comprise the atmosphere, the faster the molecules move; the faster they move, the more they tend to break away from the gravitational pull that keeps them close to the earth. Those heavenly bodies which lack atmosphere—like the planet Mercury, and all the moons of all the planets, except for Titan, the largest moon of the planet Saturn—lack it because their gravitational pull is too weak.

Q. ***What special training, if any, will space travelers require?***

HABER: They will have to be both physically sound and well informed on pertinent subjects. Besides a complete physical checkup, they probably will have to undergo tests to determine their reaction to acceleration and to weightlessness. One important requirement will be familiarity with the theory of space travel; another will be a reasonably good education in astronomy. As knowledge of space travel progresses, special tests for space aptitude doubtless will evolve; meanwhile, most of the early spacemen are likely to be pilots who have flown in jet or rocket airplanes, who are in good health, who have the necessary theoretical knowledge—and who are sufficiently versatile to deal with the wide range of problems likely to be encountered in space.

Q. ***From what places in the world could a rocket ship be launched into space?***

VON BRAUN: There are a number of places which might prove practical. The requirements are simple: any seacoast with 1,000 miles of water in an easterly direction—so that the rocket, which must be launched into space toward the east, could drop its two booster stages over water—would be satisfactory. That description applies to countless islands in various oceans; to the whole east coast of both North and South America; much of the east coast of East Asia; the east coast of the Japanese Islands; the east coast of Madagascar and Africa; and the east coast of both islands of New Zealand, plus part of the east coast of Australia (only part, because in some places either New Zealand or the Great Barrier Reef might interfere). However, it would be desirable to have islands a few hundred miles east of the launching site, from which the vessels could operate which retrieve the two booster stages. That would further restrict our choices.

Q. ***How about rocket travel on earth?***

LEY: Plans for long-range rockets which could travel between two distant points on earth have been developed by various scientists. The latest proposal, for a trip between Los Angeles and New York, is that of Dr. Hsue-shen Tsien of the California Institute of Technology. His winged rocket would rise to a top altitude of more than 300 miles, being powered for only the first third of the climb. Then it would swoop down until it reached an altitude of 27 miles, some 1,200 miles east of its take-off point; the remainder of the trip would be a supersonic glide at that height. Here are some of Dr. Tsien's figures: take-off weight, 50 tons; duration of powered flight, 150 seconds; duration of entire flight, one hour; landing speed, 150 miles per hour. Although such a rocket could be developed now, it is doubtful that a coast-to-coast rocket line would be commercially feasible at present.

Q. ***What is the temperature in space?***

KAPLAN: There isn't any. It may be hard to imagine, but since space is a vacuum it lacks temperature entirely (a vacuum is "nothing," and "nothing" cannot have a temperature). A rocket ship near the orbit of the earth would, however, have an internal temperature determined by the amount of heat it absorbed from the sun (93,000,000 miles away) on one side, and the amount of this heat it lost on its shaded side. This can be controlled to a certain degree. If the ship were of a dark (heat-absorbent) color, it would assume a temperature of about 60 degrees Fahrenheit. If its color were lighter, the temperature would be lower. And if the ship were nearer the earth, it would be somewhat warmer—because it would catch additional sunlight reflected from the earth.

Q. ***Will atomic energy be used to power a rocket ship?***

VON BRAUN: Not for some time to come. Atomic power is being developed for submarines and is

Around the Editor's Desk

planned for airplanes, but in both these cases an atomic "pile" will merely substitute for part of the conventional engine; actual propulsion will still be the work of a propeller. In a rocket ship, the rocket does its propelling by ejecting powerful gases behind it. Even if a new method of space propulsion is found, permitting the use of atomic power, an additional problem will be the heavy wall of steel or lead required to protect the crew from radiation. Furthermore, an atomic rocket motor will never be practical for launching rocket ships from the earth, because of its radioactive exhaust. In any event, we need not wait for atomic-powered rockets; known chemical fuels will do the job.

Q. ***Would the artificial air pumped into a space station or the cabin of a rocket ship have the same composition as the air that men breathe on the earth?***

LEY: As part of the necessary protection against meteorites, helium may prove a desirable substitute for the 80 per cent of nitrogen present in the air we normally breathe (the other 20 per cent could continue to be oxygen, as it is on the earth). If a meteorite punctured the skin of a space station or rocket ship, the resultant drop in air pressure would be hazardous even if the loss of oxygen could be countered by wearing masks. Like deep-sea divers brought to the surface too fast, the spacemen might suffer an attack of "the bends"—an often fatal affliction caused by the fact that some of the nitrogen we breathe forms painful and dangerous bubbles in the blood when the pressure drops suddenly outside the body. Helium does not dissolve easily in the blood stream. The Navy has tested a helium-oxygen mixture in deep-sea diving with good results.

Q. ***Considering the complicated problems posed by travel in space, how could a guided missile be fired accurately from a satellite to earth?***

VON BRAUN: The principle would be much the same as that used to fly a rocket ship from space to earth. As our space station circled the globe, the missile would be launched *in the opposite direction.* The reason is this: if the missile were simply detached from the space station, it would continue circling the earth, just like another satellite in the same orbit; if it were fired in the same direction as that in which the station was moving, it would fly off farther into space. Only if fired "backward" would it lose sufficient speed, in relation to the earth, to descend from the orbit. It would leave the station at a speed of 1,048 miles per hour; at the time it was fired, the target at which it was aimed probably would be invisible, located on the back side of the spinning earth below. The weapon would enter the atmosphere on a course roughly paralleling the surface of the earth; its position and relationship to the target (when it finally came into view of the satellite) would then be determined by radar. Remote radio control would guide the missile to its destination. Naturally, the guided projectile would not be slowed down further for its "landing," in the way that a rocket ship would be as it came close to the earth. Instead, the weapon would approach the target moving faster than the speed of sound. No place on earth, from pole to pole, would be safe from such a weapon fired from a satellite in space.

Q. ***To what tribunal would questions of space law be referred?***

SCHACHTER: A dispute in space that involved two or more governments could be submitted to the International Court of Justice at the Hague, just as international disputes are today. Naturally, precedents in such a case would be difficult to determine; but the court could apply rules expressly agreed to by the contesting governments. If no such agreement could be reached, international custom or the general principles of law might provide a guide. Alternatively, the governments might submit the case to a special court set up just to decide that one dispute. In a dispute between individuals, rather than governments, jurisdiction might lie with a local court in the place where the individuals normally lived, or perhaps with a court where the space station or rocket ship involved was registered.

Q. ***What, specifically, would be bought by the $4,000,000,000 estimated as the cost of establishing a station in space?***

VON BRAUN: The great bulk of the money would be spent for experimentation, testing, construction of a fuel-producing plant, and other preliminaries to a permanent space program. Once the initial phases of the program had been paid for, costs would drop abruptly. For example, it would be necessary to make special high-altitude test shots with unmanned rockets before actually proceeding with the establishment of a space station. This might involve constructing and firing into space a small version of the three-stage rocket that promises to be the main space vehicle of the immediate future. This small model would be sent into the "two-hour" orbit later to be occupied by the artificial satellite; instruments inside the rocket, employing methods already in use, would transmit vital information back to earth. The fuel to be used in our projected space travels would consist of nitric acid and hydrazine; the first of these ingredients is being mass-produced for commercial use, but special factories would have to be built to manufacture the hydrazine, which has little commercial application at present. In short, the $4,000,000,000 would buy everything from the paper on which the experts did their initial calculations to the circling space station itself. Perhaps a dozen cargo-carrying rocket ships would be needed to carry the components of the station to its orbit around the earth; thereafter, presumably, production of rocket ships would continue. As an indication of how expenses would drop once the project was under way, the ultimate cost of these rocket-powered vehicles probably would be less than $1,000,000 each—no more than the current purchase price of a large air liner.

Q. ***Is there life on other planets?***

LEY: Most astronomers agree that there is primitive plant life, like lichens and algae, on Mars. The presence of this potential food supply has led a number of biologists (although not all of them) to conclude that there may be some form of animal life there, too. It is very doubtful that life of any kind exists on the other planets, however. The five which are farthest from the essential warmth of the sun—Jupiter, Saturn, Uranus, Neptune and Pluto—are much too cold to support life as we know it. Venus, which is closer to the sun than we are, is considered too hot. Peculiarly, Mercury, which is closest of all to the sun, offers the only other possibility of life. That's because Mercury keeps one face turned constantly toward the sun, just as our moon shows only one side to the earth. The "daylight" side of Mercury is extremely hot—hot enough to melt lead. Its "night" side is correspondingly cold. However, these two extremes are separated by a so-called "twilight belt," where temperatures approach those of the earth and Mars. It is just conceivable that life may have taken hold in that dim, narrow strip between the unbearable heat of Mercury's daylight and the terrible cold of its night.

Q. ***Would Soviet Russia enjoy any advantages in a race for space superiority?***

VON BRAUN: Just one advantage of any importance, so far as is known. Because the country is huge, and barricaded behind the Iron Curtain, the initial phases of a space program could be kept secret much more easily in the Soviet Union than in the Western World. One other advantage *may* exist: the Soviets claim a head start. There is no way of telling whether that is true. Obviously, there are several conditions which must be met before any nation could establish a satellite in space, and thus assume space superiority. First, of course, that country would need trained rocket researchers. Whether the U.S.S.R. has such scientists in any number (and of sufficient caliber) is uncertain. Of the experts who gave Germany its enormous lead in rocketry during World War II, only one, Helmuth Groettrup, is working for the Soviet Union; several are employed by the United States. Another major requirement is a highly diversified industrial economy; in this respect, the United States is certainly far advanced over Soviet Russia. Finally, in the matter of the necessary natural resources, it is doubtful that either side has an advantage. The raw materials needed for a space program are fairly common and probably are as easily available in the U.S.S.R. as in the West. Summing up, the advantage in the competition to conquer space probably rests with us—if we move quickly.

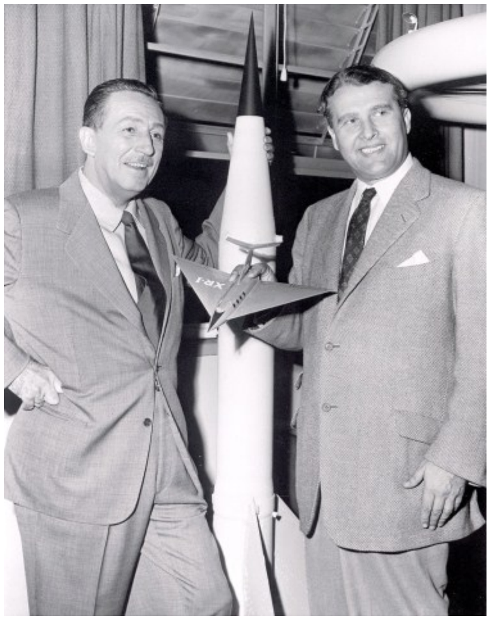
DRAWINGS BY LOWELL HESS

Collier's 3/22/52

We noticed this recent blog entry about Man Will Conquer Space Soon!:

http://blogs.smithsonianmag.com/paleofuture/2012/07/wernher-von-brauns-martian-chronicles/

Right: Walt Disney, left, and Wernher von Braun, right. Dr. Werhner von Braun, then Chief, Guided Missile Development Operation Division at Army Ballistic Missile Agency (ABMA) in Redstone Arsenal, Alabama, was visited by Walt Disney in 1954. In the 1950's, von Braun worked with Disney Studio as a technical director, making three films about space exploration for television. A model of the V-2 rocket is in background. 1 January 1954. Image source: Wikipedia. Image credit: NASA.



Right: This note is from page 90 of the March 22, 1952 issue, the first of eight issues of Collier's in this series. Image credit: Douglas Yazell. Thanks to UNZ.org for making this page visible to everyone.

Collier's Editorials *normally appear on this page. This week, however, our editorial– dealing with the need for immediate federal action on a projected station in space– is an integral part of the special symposium on space travel that is a feature of this issue. It will be found on pages 22 and 23.*

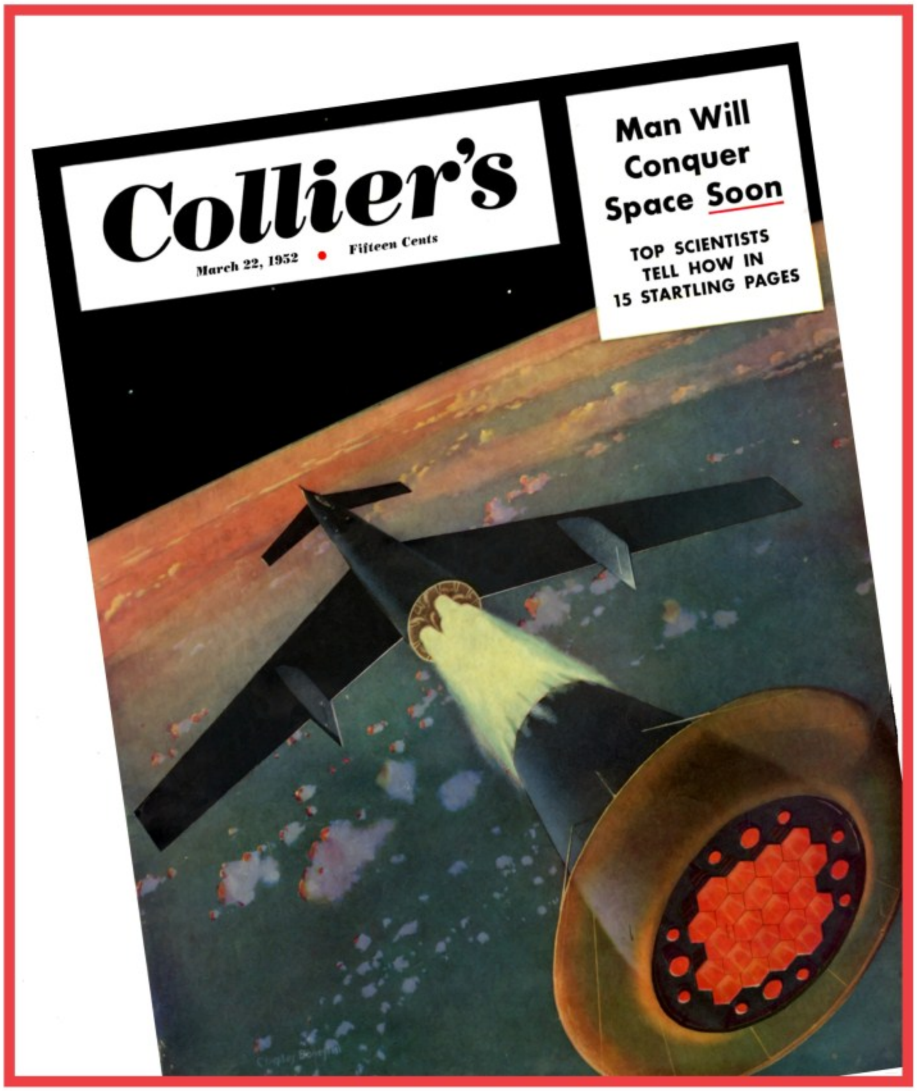
Right: A recreation of "The Cover," a text box from page six of the March 22, 1952, issue of Collier's. Image credit: Douglas Yazell. Thanks to UNZ.org for making this page visible to everyone.

The Cover

Accurate to the last, minute specification, the cover painting that is this week's frontispiece shows the staggering climax of man's first flight into the unknown reaches of space. At this precise moment in its journey, the nose section (third stage), containing crew and cargo, has disengaged itself from the second booster rocket unit. While the nose soars on and up in a northeasterly direction from this point 40 miles in the air, the steel mesh parachute of the second booster has opened and begins the long drop into the Pacific Ocean below. For the full story of man's inevitable invasion of the heavens, dramatically illustrated and simply told, turn to page 22.

On the following page is a reproduction by Scott Lowther of a full-page editorial from page 74 of the October 11, 1952 issue of Collier's. It is a preview of the second of eight issues of Collier's containing articles in the series, "Man Will Conquer Space Soon!" That second issue was the October 18, 1952 issue, a long wait after the first issue of March 22, 1952. Thanks to UNZ.org for making that page visible for everyone.

Also on the following page is a preview of the October 18, 1952 issue. The preview appeared on page 32 of the October 11, 1952 issue. Since the last paragraph of the editorial was not related to space exploration, it is a good place to present this small peek at what is coming next in Horizons. Reproduction of that preview was done by Douglas Yazell, who was born between the first and second issues in this series. Thanks to UNZ.org for making this visible to everyone.



Next Comes the Moon

THE ILLUSTRATION for this week's editorial will be familiar to most Collier's readers, for it was the cover of our issue of March 22, 1952, which contained a number of articles under the collective title Man Will Conquer Space Soon. Since that issue appeared, some things have occurred which we believe lend strength to our slogan, Collier's Makes Things Happen.

For one thing, an expanded version of those March 22d articles appeared last week as a book called Across the Space Frontier (Viking Press), and already its sales are right up there in the hot-cake category. For another, the Third International Congress on Astronautics met in Stuttgart, Germany, a few weeks before to discuss the conquest of space.

Now, we don't say that Collier's made this Stuttgart conference happen. But our March 22d issue did anticipate and deal with the very same subjects that the 200 scientists from 13 countries discussed in Stuttgart, from the cost, design and time factors involved in constructing a space rocket, to the technical problems of building an artificial satellite in outer space and the legal problems regarding possession and "ownership" of that space. And while Dr. Wernher von Braun, who wrote our leading article on space travel, was not able to appear in person at the astronautical congress, his paper on Space Travel: A Common International Task, which was read before the conference, was one of the key documents of the discussion.

The very fact that the word astronautical exists in our language seems proof enough to us that space travel has passed from the realm of conjecture to the field of rather imminent reality. There are many difficulties to overcome. But the technical details have been worked out beyond the point of doubt or failure. And in working them out the astronauts have succeeded in making science fact vastly stranger and more intriguing than science fiction. The fanciful activities of the space travelers met in comic books, television and movies can't compare with what actual men will accomplish within the lifetime of many of us.

For man *will* conquer space. There is no longer any real question about it. It is the last great frontier that challenges human intelligence, ingenuity and courage. And, as the title of Dr. von Braun's paper states, the meeting of that challenge is a common international task. It is also a disturbing international problem.

The development of rockets, upon which space travel depends, was born of the desire for destruction and conquest in World War II. It might now—and in a happier period of world history it surely would—become an instrument for opening vast new horizons to the traditionally nonpolitical, non-nationalistic, peaceable brotherhood of world scientists. But, in the Soviet Union, political theory has long since taken over science and warped and perverted it to political uses. Thus true international co-operation in the conquest of space is impossible.

Whether the free world's scientists will pool their wisdom, or whether the United States will have to go it alone in the conquest of space, remains to be seen. But Collier's believes that it behooves this country to start some real activity. For the first power that builds and occupies a space satellite will hold the ultimate military power over all the earth. This the Soviet government knows, too, and it is not idle.

In the hands of a peaceful country like ours, a space satellite would be the first step in a series of infinite and perhaps unimagined possibilities. For it must be remembered that an artificial satellite, though a staggering accomplishment, would be only a beginning. Beyond this threshold of outer space lies the moon, and beyond the moon the nearer planets.

Collier's told you the details of the first step last March, but we haven't neglected outer space in the meantime. In next week's issue and the issue following we shall bring you the story of Man on the Moon, by the same scientists who conducted our first symposium. It's a feasible, technically accurate story and a highly important one, too, because it is someday going to come true.

Next Week

MAN ON THE MOON

Scientists Tell How We Can Land There In Our Lifetime

Collier's

OCTOBER 18, 1952 • FIFTEEN CENTS

MAN ON THE MOON

Scientists Tell How We Can Land There In Our Lifetime

MAN on the MOON

Scientists have dreamed for centuries of a lunar voyage. Now we know it can be done within the next 25 years—if we get started right away. In this symposium, a distinguished panel tells how

WE WILL go to the moon in the next 25 years. We have the knowledge and the tools to do it now, but years of preparation and detailed planning are needed first. What we *can* do now is get the project started.

The first step has been taken: our scientists have developed rockets which have shot through the earth's atmosphere into airless space beyond. All we need now are better rockets—and we know how to build them.

Our trip to the moon will not be a simple nonstop flight from the earth. We'd need too large and expensive a rocket ship for that. Instead, we'll make a stopover in space. We'll change vehicles, shifting from one especially designed to break away from the earth's atmosphere into one specifically designed for a moon voyage. There will be other advantages to a two-step trip, too, among them a 15,840-mile-an-hour running start on the second leg of the journey. Here's how it's done:

Within the next 10 or 15 years, we can expect to see a permanent station erected in space, 1,075 miles high, in an orbit which will carry it around the earth once every two hours. The details of this project were given in Collier's issue of March 22, 1952.

The station will be built of materials carried to the two-hour orbit by great rocket ships—called three-stage rockets because they will have three separate batteries of motors to be used one at a time, then dropped off. At a speed of 15,840 miles an hour, 1,075 miles up, these rockets become satellites of the earth, unaffected by gravity. Without power, they will cruise around the globe as long as we let them. Their cargo will do the same, since it travels at the same speed. So we merely unload our building supplies in space and let them drift there until needed.

From these prefabricated parts, we'll build a wheel-shaped structure 250 feet in diameter, with pressurized compartments and a crew of 80. The space station's ability to scan all parts of the earth will make it one of the most powerful forces for peace ever developed—or, in the wrong hands, a terrible weapon of war. Collier's still believes that the station must be built by free men; that means the United States, the only nation which can afford the satellite's $4,000,000,000 cost. In 1948, the late Secretary of Defense James V. Forrestal indicated that work on an earth satellite program had already begun. It should not be allowed to lag.

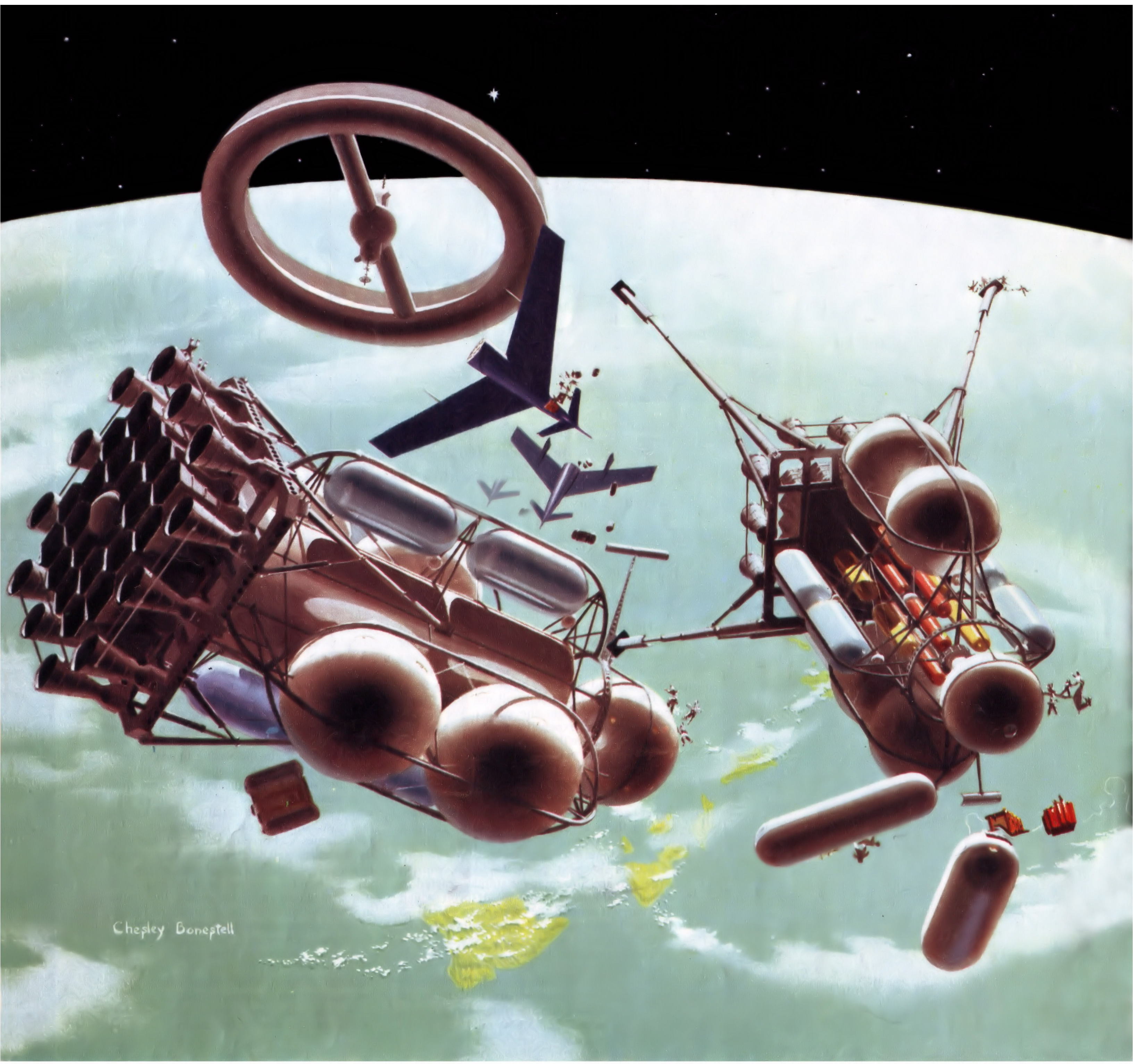
For, besides serving as a roving, ever-watchful guardian of the peace, the station in space will provide the springboard for one of the greatest scientific advances in history: the lunar journey men have dreamed of for centuries. The space station should be a reality by 1967. By the time it's completed, many of the preliminary plans will be ready for the next long step into space.

By 1977, the first scientists may set foot on the ancient dust of the moon.

HANS KNOPF

Contributors to symposium: Willy Ley, left, writer on scientific subjects; Dr. Fred L. Whipple, chairman of Harvard University astronomy department; Dr. Wernher von Braun, world's top rocket expert; artists Chesley Bonestell, Rolf Klep, Fred Freeman; associate editor Cornelius Ryan, who assembled material

MOON PHOTO COURTESY LICK OBSERVATORY



Weightless in orbit 1,075 miles above earth, workers in space suits assemble three moon ships. Hawaiian Islands lie below. Winged transports unload

Man on the Moon

THE JOURNEY

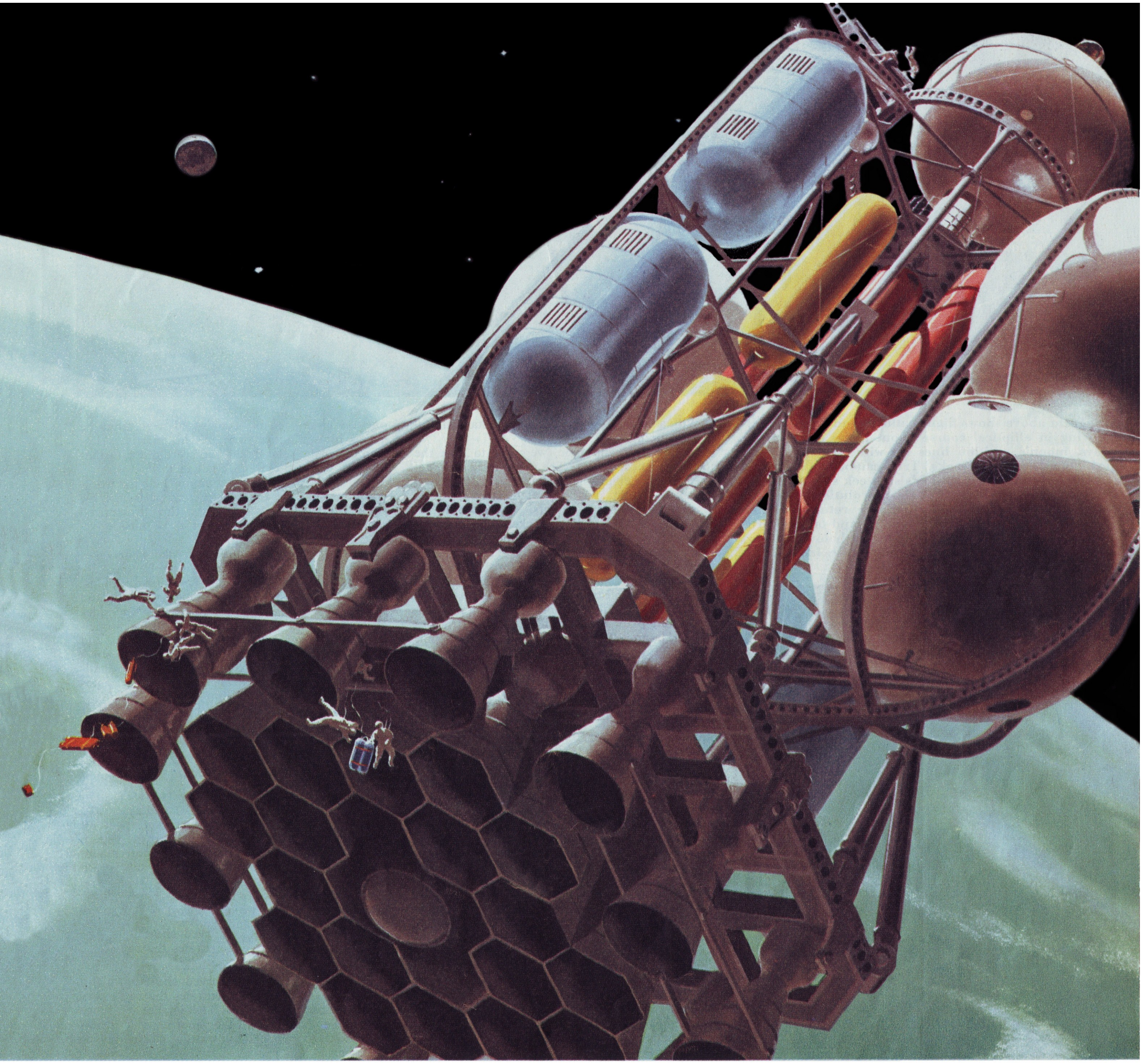
By DR. WERNHER von BRAUN

Technical Director, Army Ordnance Guided Missiles Development Group, Redstone Arsenal, Huntsville, Alabama

For five days, the expedition speeds through space on its historic voyage —50 men on three ungainly craft, bound for the great unknown

HERE is how we shall go to the moon. The pioneer expedition, 50 scientists and technicians, will take off from the space station's orbit in three clumsy-looking but highly efficient rocket ships. They won't be streamlined: all travel will be in space, where there is no air to impede motion. Two will be loaded with propellant for the five-day, 239,000-mile trip and the return journey. The third, which will not return, will carry only enough propellant for a one-way trip; the extra room will be filled with supplies and equipment for the scientists' six-week stay.

On the outward voyage, the rocket ships will hit a top speed of 19,500 miles per hour about 33 minutes after departure. Then the motors will be stopped, and the ships will fall the rest of the way to the moon.



supplies near wheel-shaped space station top left. Engineers and equipment cluster around cargo ship lower left, passenger ships center and right

Such a trip takes a great deal of planning. For a beginning, we must decide what flight path to follow, how to construct the ships and where to land. But the project could be completed within the next 25 years. There are no problems involved to which we don't have the answers—or the ability to find them—right now.

First, where shall we land? We may have a wide choice, once we have had a close look at the moon. We'll get that look on a preliminary survey flight. A small rocket ship taking off from the space station will take us to within 50 miles of the moon to get pictures of its meteor-pitted surface—including the "back" part, never visible from the earth.

We'll study the photographs for a suitable site. Several considerations limit our selection. Because the moon's surface has 14,600,000 square miles—about one thirteenth that of the earth—we won't be able to explore more than a small area in detail, perhaps part of a section 500 miles in diameter. Our scientists want to see as many kinds of lunar features as possible, so we'll pick a spot of particular interest to them. We want radio contact with the earth, too; that means we'll have to stick to the moon's "face," for radio waves won't reach across space to any point the eye won't reach.

We can't land at the moon's equator because its noonday temperatures reach an unbearable 220-degrees Fahrenheit, more than hot enough to boil water. We can't land where the surface is too rugged, because we need a flat place to set down. Yet the site can't be too flat, either—grain-sized meteors constantly bombard the moon at speeds of several miles a second; we'll have to set up camp in a crevice where we have protection from these bullets.

There's one section of the moon that meets all our requirements, and unless something better turns up on closer inspection, that's where we'll land. It's an area called *Sinus Roris*, or Dewy Bay, on the northern branch of a plain known as *Oceanus Procellarum*, or Stormy Ocean (so called by early astronomers who thought the moon's plains were great seas). Dr. Fred L. Whipple, chairman of Harvard University astronomy department, says *Sinus Roris* is ideal for our purpose—about 650 miles from the lunar north pole, where the daytime temperature averages a reasonably pleasant 40 degrees and the terrain is flat enough to land on, yet irregular enough to hide

PAINTING BY CHESLEY BONESTELL

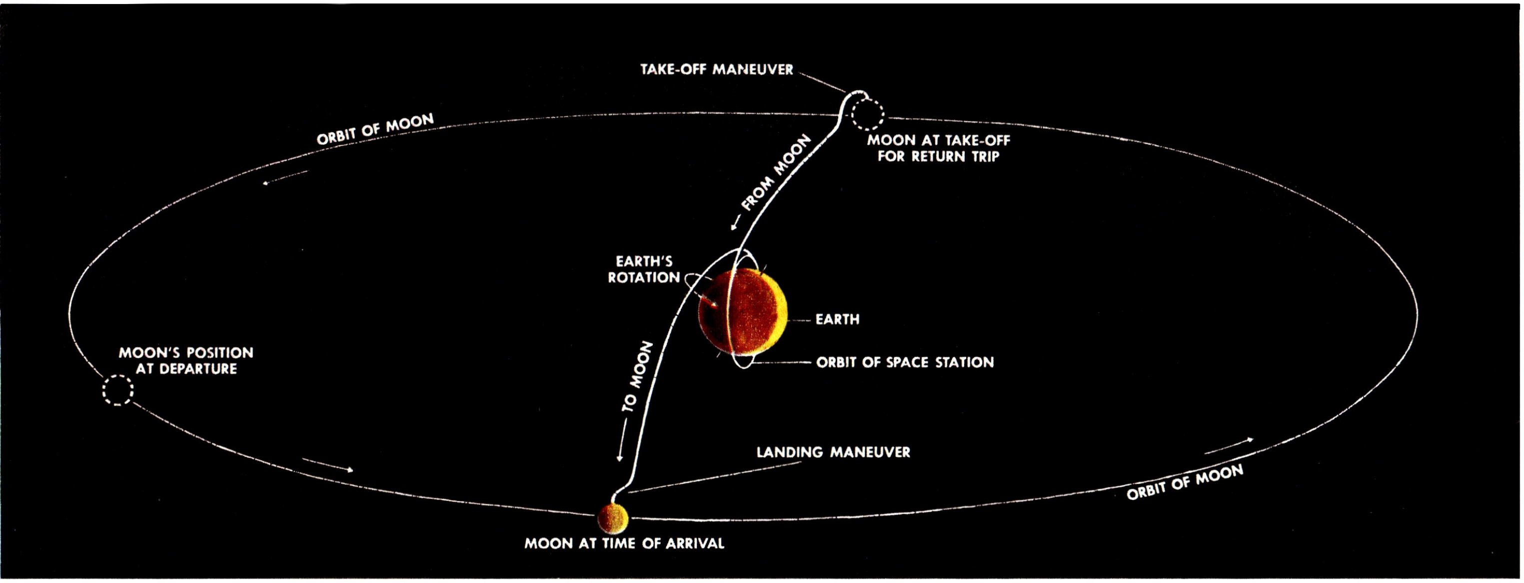
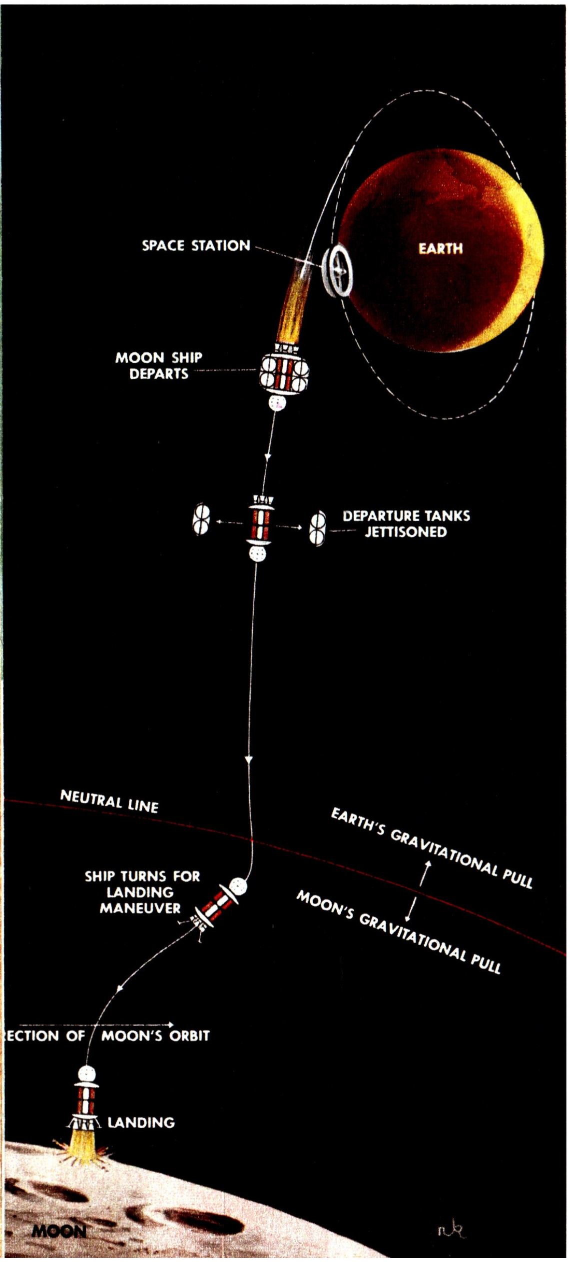


Diagram above shows flight paths to and from moon. Moving in elliptical course about globe every 27⅓ days, moon's position lines up with space station's orbit once every two weeks. Trips can be made only at this time. During expedition's six-week stay on lunar surface, moon will make 1½ revolutions around earth to reach correct position for return. Slight curves in flight track during landing and take-off are caused by moon's gravity. Drawing below, not in scale, shows moon-bound flight maneuvers in close-up



in. With a satisfactory site located, we start our detailed planning.

To save fuel and time, we want to take the shortest practical course. The moon moves around the earth in an elliptical path once every 27⅓ days. The space station, our point of departure, circles the earth once every two hours. Every two weeks, their paths are such that a rocket ship from the space station will intercept the moon in just five days. The best conditions for the return trip will occur two weeks later, and again two weeks after that. With their stay limited to multiples of two weeks, our scientists have set themselves a six-week limit for the first exploration of the moon—long enough to accomplish some constructive research, but not long enough to require a prohibitive supply of essentials like liquid oxygen, water and food.

Six months before our scheduled take-off, we begin piling up construction materials, supplies and equipment at the space station. This operation is a massive, impressive one, involving huge, shuttling cargo rocket ships, scores of hard-working handlers, and tremendous amounts of equipment. Twice a day, pairs of sleek rocket transports from the earth sweep into the satellite's orbit and swarms of workers unload the 36 tons of cargo each carries. With the arrival of the first shipment of material, work on the first of the three moon-going space craft gets under way, picking up intensity as more and more equipment arrives.

The supplies are not stacked inside the space station; they're just left floating in space. They don't have to be secured, and here's why: the satellite is traveling around the earth at 15,840 miles an hour; at that speed, it can't be affected by the earth's gravity, so it doesn't fall, and it never slows down because there's no air resistance. The same applies to any other object brought into the orbit at the same speed: to park beside the space station, a rocket ship merely adjusts its speed to 15,840 miles per hour; and it, too, becomes a satellite. Crates moved out of its hold are traveling at the same speed in relation to the earth, so they also are weightless satellites.

As the weeks pass and the unloading of cargo ships continues, the construction area covers several littered square miles. Tons of equipment lie about—aluminum girders, collapsed nylon-and-plastic fuel tanks, rocket motor units, turbopumps, bundles of thin aluminum plates, a great many nylon bags containing smaller parts. It's a bewildering scene, but not to the moon-ship builders. All construction parts are color-coded—with blue-tipped cross braces fitting into blue sockets, red joining members keyed to others of the same color, and so forth. Work proceeds swiftly.

In fact, the workers accomplish wonders, considering the obstacles confronting a man forced to struggle with unwieldy objects in space. The men move clumsily, hampered by bulky pressurized suits equipped with such necessities of space-life as air conditioning, oxygen tanks, walkie-talkie radios and tiny rocket motors for propulsion. The work is laborious, for although objects are weightless they still have inertia. A man who shoves a one-ton girder makes it move all right, but he makes himself move, too. As his inertia is less than the girder's, he shoots backward much farther than he pushes the big piece of metal forward.

The small personal rocket motors help the workers move some of the construction parts; the big stuff is hitched to space taxis, tiny pressurized rocket vehicles used for short trips outside the space station.

As the framework of the new rocket ships takes form, big, folded nylon-and-plastic bundles are brought over. They're the personnel cabins; pumped full of air, they become spherical, and plastic astrodomes are fitted to the top and sides of each. Other sacks are pumped full of propellant, and balloon into the shapes of globes and cylinders. Soon the three moon-going space ships begin to emerge in their final form. The two round-trip ships resemble an arrangement of hourglasses inside a metal framework; the one-way cargo carrier has much the same framework, but instead of hourglasses it has a central structure which looks like a great silo.

Dimensions of the Rocket Ships

Each ship is 160 feet long (nine feet more than the height of the Statue of Liberty) and about 110 feet wide. Each has at its base a battery of 30 rocket motors, and each is topped by the sphere which houses the crew members, scientists and technicians on five floors. Under the sphere are two long arms set on a circular track which enables them to rotate almost a full 360 degrees. These light booms, which fold against the vehicles during take-off and landing to avoid damage, carry two vital pieces of equipment: a radio antenna dish for short-wave communication and a solar mirror for generating power.

The solar mirror is a curved sheet of highly polished metal which concentrates the sun's rays on a mercury-filled pipe. The intense heat vaporizes the mercury, and the vapor drives a turbo-generator, producing 35 kilowatts of electric power—enough to run a small factory. Its work done, the vapor cools, returns to its liquid state and starts the cycle all over again.

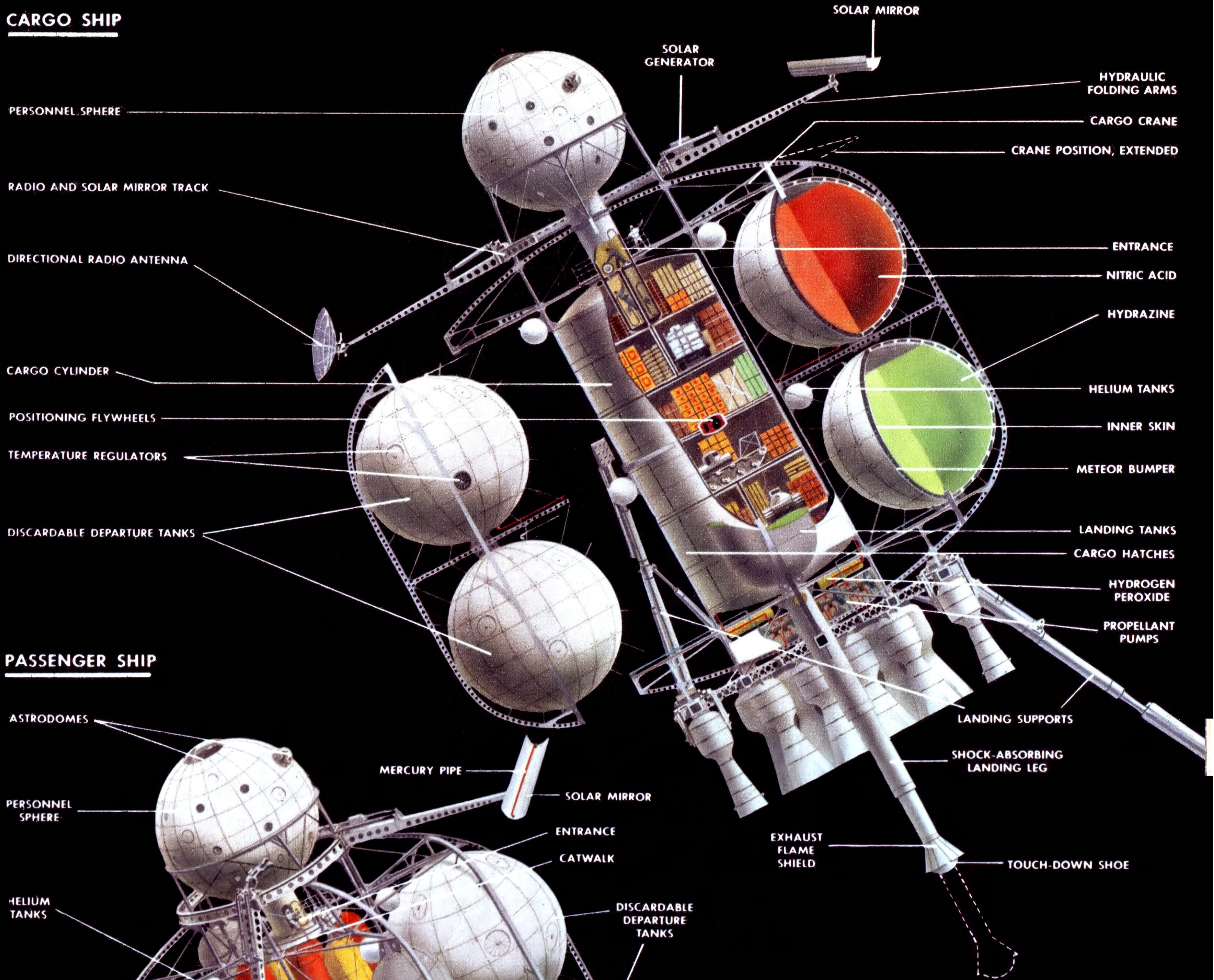
Under the radio and mirror booms of the passenger ships hang 18 propellant tanks carrying nearly 800,000 gallons of ammonialike hydrazine (our fuel) and oxygen-rich nitric acid (the combustion agent). Four of the 18 tanks are outsized spheres, more than 33 feet in diameter. They are attached to light frames on the outside of the rocket ship's structure. More than half our propellant supply—580,000 gallons—is in these large balls; that's the amount needed for take-off. As soon as it's exhausted, the big tanks will be jettisoned. Four other large tanks carry propellant for the landing; they will be left on the moon.

We also carry a supply of hydrogen peroxide

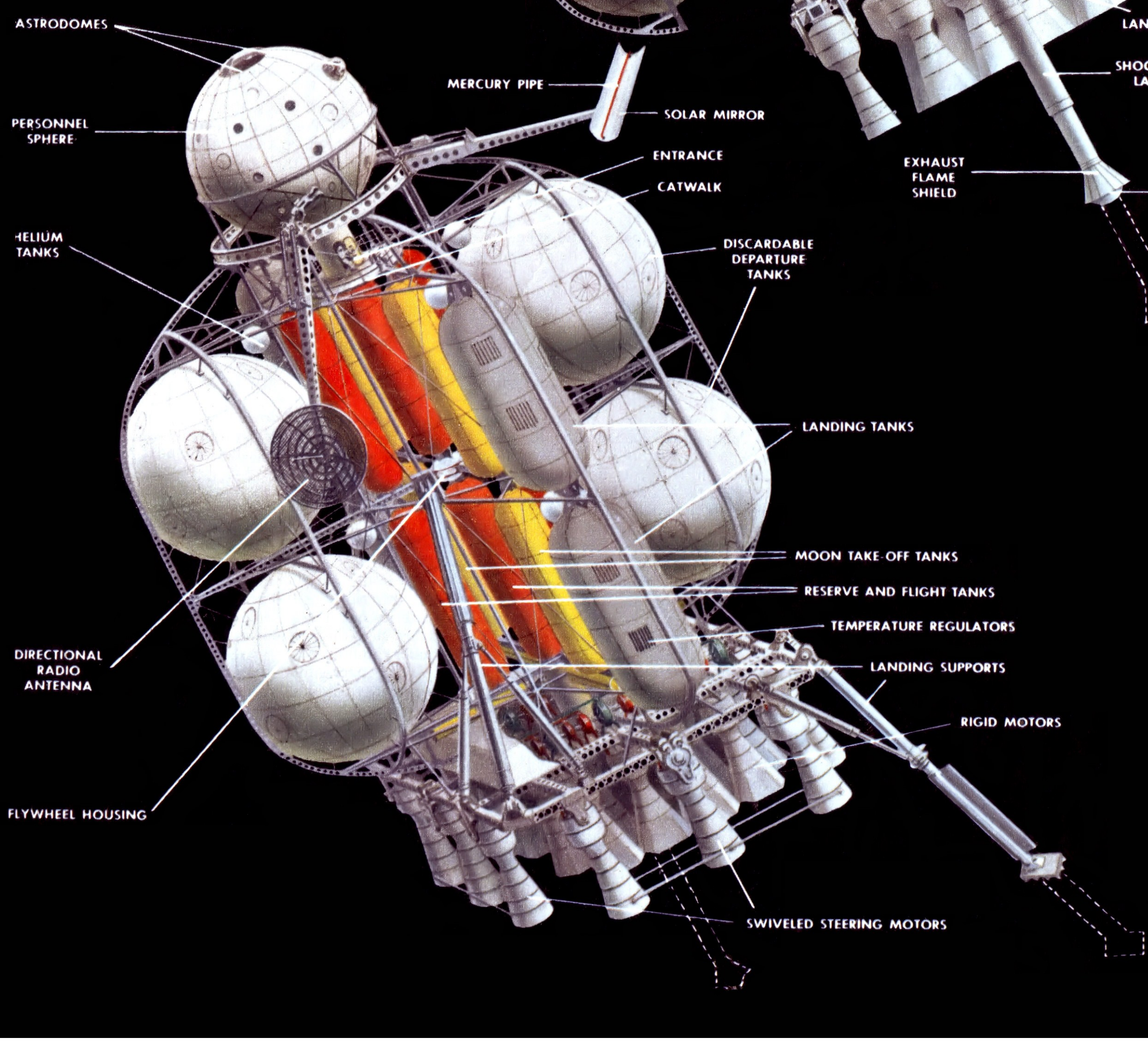
Vehicles, right, have same dimensions: 160 ft. long, 110 ft. wide; weigh 4,370 tons. Cargo ship carries 10 men, passenger ships 20 each

DRAWINGS BY ROLF KLEP

CARGO SHIP



PASSENGER SHIP



to run the turbopumps which force the propellant into the rocket motors. Besides the 14 cylindrical propellant tanks and the four spherical ones, eight small helium containers are strung throughout the framework. The lighter-than-air helium will be pumped into partly emptied fuel tanks to help them keep their shape under acceleration and to create pressure for the turbopumps.

The cost of the propellant required for this first trip to the moon, the bulk of it used for the supply ships during the build-up period, is enormous—about $300,000,000, roughly 60 per cent of the half-billion-dollar cost of the entire operation. (That doesn't count the $4,000,000,000 cost of erecting the space station, whose main purpose is strategic rather than scientific.)

The cargo ship carries only enough fuel for a one-way trip, so it has fewer tanks: four discardable spheres like those on the passenger craft, and four cylindrical containers with 162,000 gallons of propellant for the moon landing.

In one respect, the cargo carrier is the most interesting of the three space vehicles. Its big silo-like storage cabin, 75 feet long and 36 feet wide, was built to serve a double purpose. Once we reach the moon and the big cranes folded against the framework have swung out and unloaded the 285 tons of supplies in the cylinder, the silo will be detached from the rest of the rocket ship. The winch-driven cables slung from the cranes will then raise *half* of the cylinder, in sections, which it will deposit on trailers drawn by tractors. The tractors will take them to a protective crevice on the moon's surface, at the place chosen for our camp. Then the other lengthwise half will be similarly moved—giving us two ready-to-use Quonset huts.

Now that we have our space ships built and have provided ourselves with living quarters for our stay on the moon, a couple of important items remain: we must protect ourselves against two of the principal hazards of space travel, flying meteors and extreme temperatures.

For Protection Against Meteors

To guard against meteors, all vital parts of the three craft—propellant tanks, personnel spheres, cargo cabin—are given a thin covering of sheet metal, set on studs which leave at least a one-inch space between this outer shield and the inside wall. The covering, called a meteor bumper, will take the full impact of the flying particles (we don't expect to be struck by any meteors much larger than a grain of sand) and will cause them to disintegrate before they can do damage.

For protection against excessive heat, all parts of the three rocket ships are painted white, because white absorbs little of the sun's radiation. Then, to guard against cold, small black patches are scattered over the tanks and personnel spheres. The patches are covered by white blinds, automatically controlled by thermostats. When the blinds on the sunny side are open, the spots absorb heat and warm the cabins and tanks; when the blinds are closed, an all-white surface is exposed to the sun, permitting little heat to enter. When the blinds on the shaded side are open, the black spots radiate heat and the temperature drops.

Now we're ready to take off from the space station's orbit to the moon.

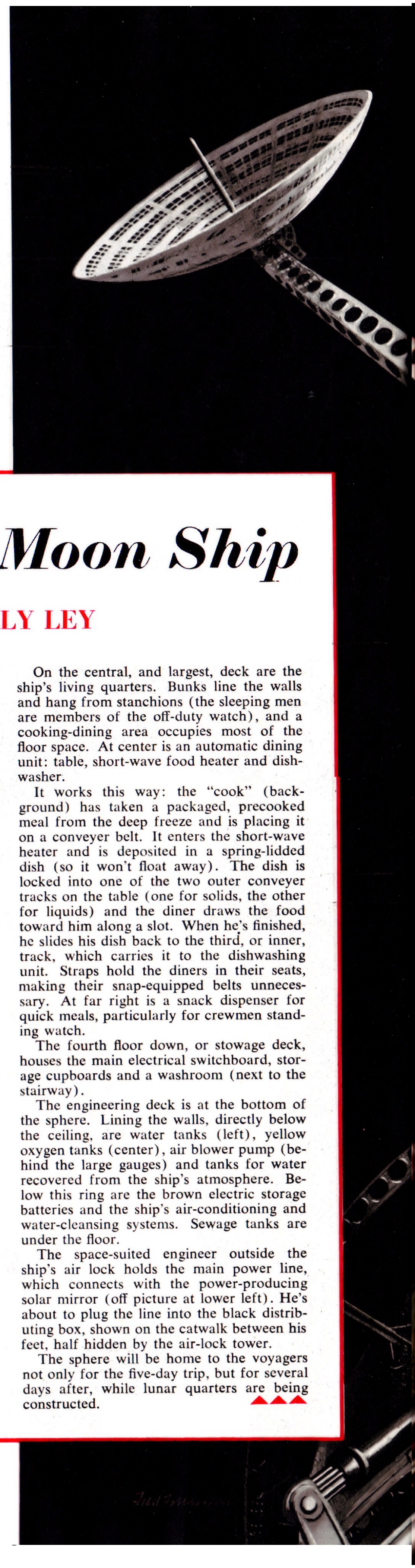
The bustle of our departure—hurrying space taxis, the nervous last-minute checks by engineers, the loading of late cargo and finally the take-off itself—will be watched by millions. Television cameras on the space station will transmit the scene to receivers all over the world. And people on the earth's dark side will be able to turn from their screens to catch a fleeting glimpse of light—high in the heavens—the combined flash of 90 rocket motors, looking from the earth like the sudden birth of a new, short-lived star.

Our departure is slow. The big rocket ships rise ponderously, one after the other, green flames streaming from their batteries of rockets, and then they pick up speed. Actually, we don't need to gain *much* speed. The velocity required to get us to our destination is 19,500 miles an hour, but we've had a running start; while "resting" in the space station's orbit, we were really streaking through space at 15,840 miles an hour. We need an additional 3,660 miles an hour.

Thirty-three minutes from take-off we have it. Now we cut off our motors; momentum and the moon's gravity will do the rest.

The moon itself is visible to us as we coast through space, but it's so far off to one side that it's hard to believe we won't miss it. In the five days of our journey, though, it will travel a great distance, and so will we; at the end of that time we shall reach the farthest point, or apogee, of our elliptical course, and the moon should be right in front of us.

The earth is visible, too—an enormous ball, most of it bulking pale black against the deeper black of space, but with a wide crescent of daylight where the sun strikes it. Within the crescent, the continents enjoying summer stand out as vast green terrain maps surrounded by the brilliant



Inside the Moon Ship

By WILLY LEY

ABOARD the moon ships, living is cramped, but not uncomfortable. Each of the two passenger vehicles holds 20 men en route to the moon, 25 on the return trip (the 10 men on the one-way cargo ship will split up coming back). For added safety, each passenger ship carries enough oxygen (three pounds per man per day), water (four pounds per man per day) and food for the *entire* expedition.

The top floor of the personnel sphere is the control deck. At the far left, an engineer keeps watch over fuel, temperature, pressure, oxygen and other gauges. Next to him, the radio operator maintains contact with the other two ships and the space station. At center, a member of the navigation staff, using a combination telescope-celestial camera, sights on a star. (When not in use, astrodomes are closed off by shutters to block the sun's blinding glare.)

To the right of his position is the rocket motor instrument panel and, underneath, the automatic pilot and the reels of tape which operate it during landing. The man at extreme right is the crew captain, strapped into a swivel seat which enables him to watch either the master controls, as he's doing now, or the motor instruments behind him (for comfort, all seats are contour seats; personnel must be strapped in so they won't float away in the weightless ship). A control board at the captain's position enables him to operate the rocket motors, and the intercom unit by his hand keeps him in communication with the rest of the ship.

The next floor down is primarily a navigation deck, although a sponge-bath stall (there are no showers, because the water won't fall properly) and extra bunks are also installed here. Next to the bathing stall, a navigator operates a mechanical computer. The chief navigator and two assistants are working at the dead-reckoning tracer, a device which automatically records the space ship's course. The clock on the wall shows elapsed time since departure, and the three screens at the right indicate the attitude of the ship, as determined by an artificial horizon mechanism in the astrodome at far right.

On the central, and largest, deck are the ship's living quarters. Bunks line the walls and hang from stanchions (the sleeping men are members of the off-duty watch), and a cooking-dining area occupies most of the floor space. At center is an automatic dining unit: table, short-wave food heater and dishwasher.

It works this way: the "cook" (background) has taken a packaged, precooked meal from the deep freeze and is placing it on a conveyer belt. It enters the short-wave heater and is deposited in a spring-lidded dish (so it won't float away). The dish is locked into one of the two outer conveyer tracks on the table (one for solids, the other for liquids) and the diner draws the food toward him along a slot. When he's finished, he slides his dish back to the third, or inner, track, which carries it to the dishwashing unit. Straps hold the diners in their seats, making their snap-equipped belts unnecessary. At far right is a snack dispenser for quick meals, particularly for crewmen standing watch.

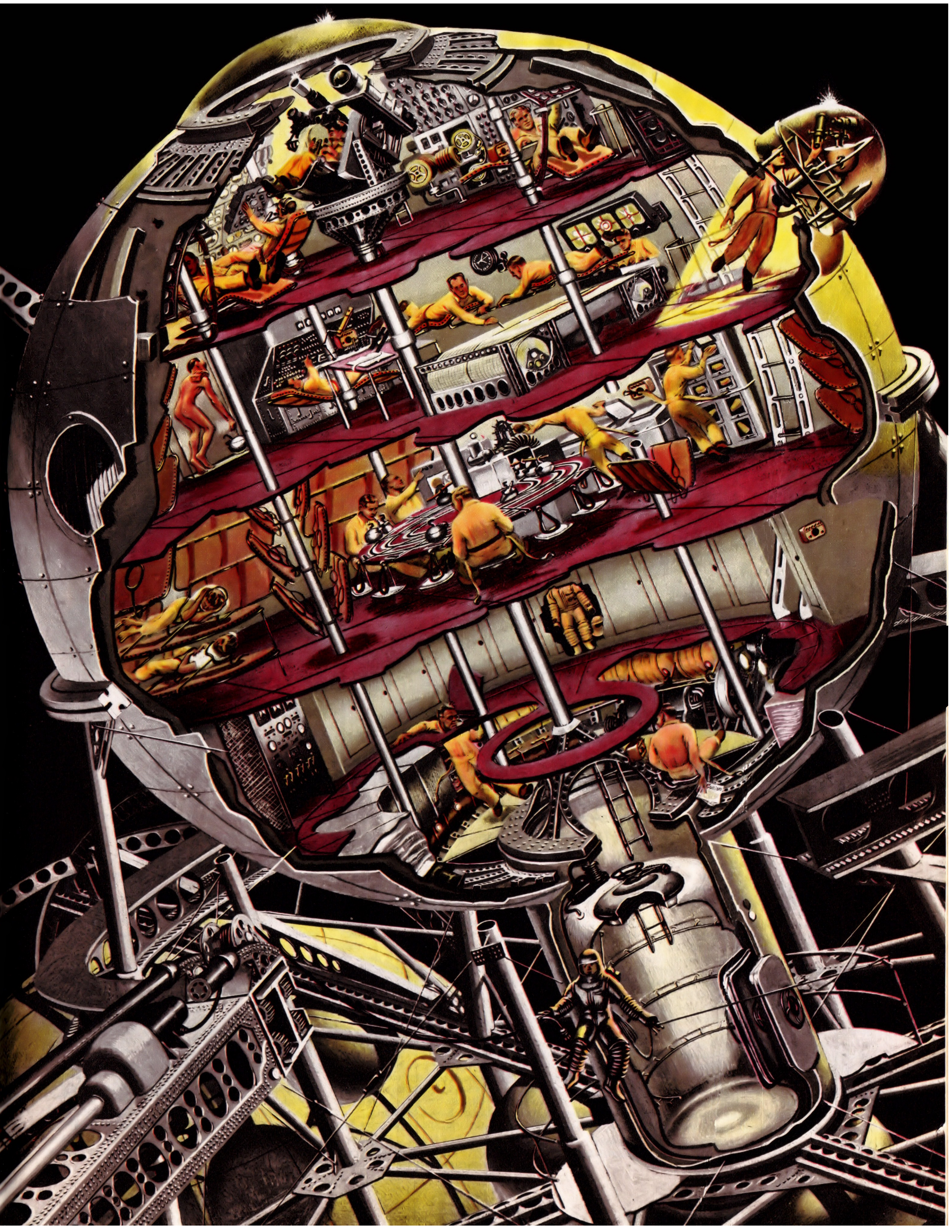
The fourth floor down, or stowage deck, houses the main electrical switchboard, storage cupboards and a washroom (next to the stairway).

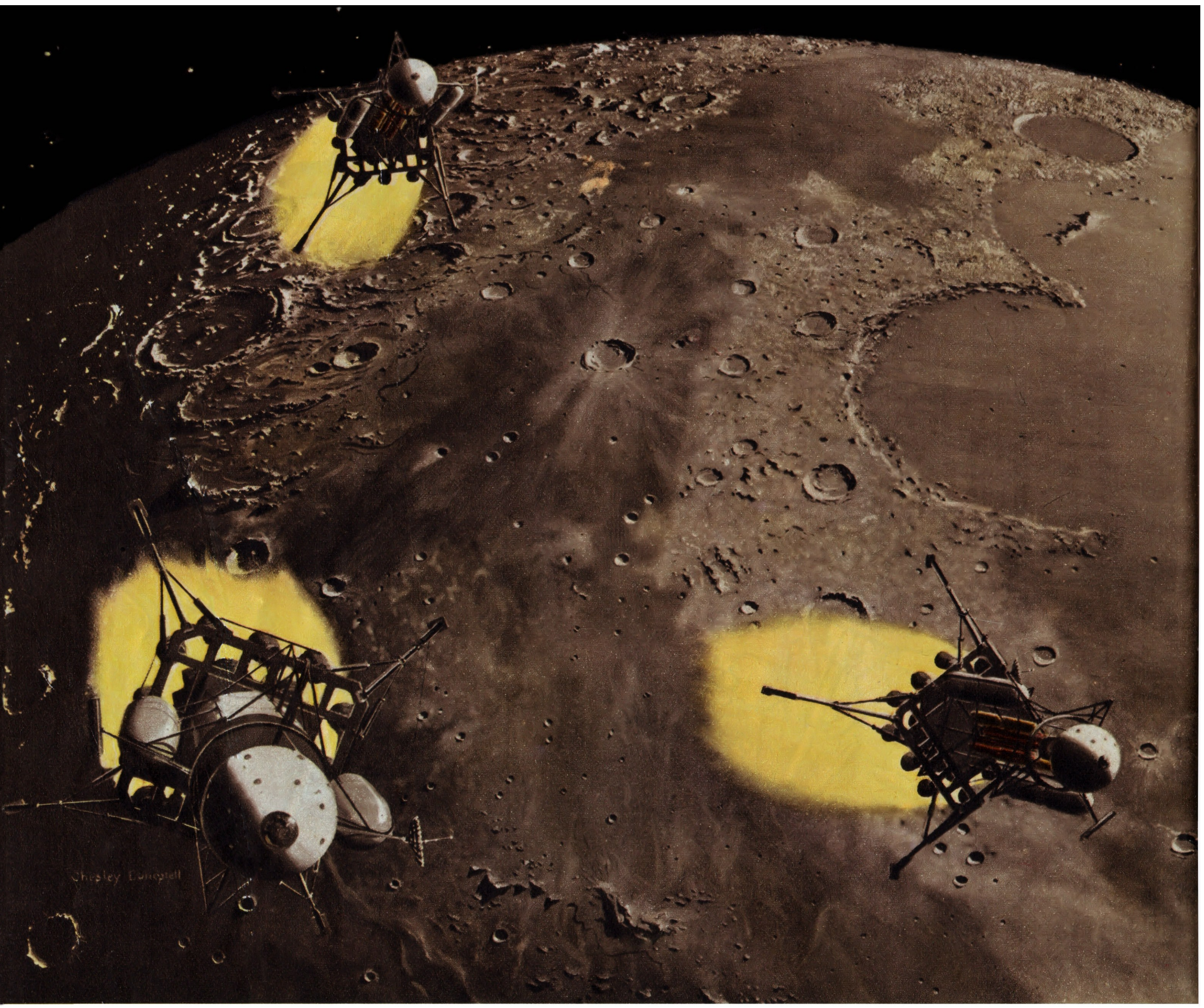
The engineering deck is at the bottom of the sphere. Lining the walls, directly below the ceiling, are water tanks (left), yellow oxygen tanks (center), air blower pump (behind the large gauges) and tanks for water recovered from the ship's atmosphere. Below this ring are the brown electric storage batteries and the ship's air-conditioning and water-cleansing systems. Sewage tanks are under the floor.

The space-suited engineer outside the ship's air lock holds the main power line, which connects with the power-producing solar mirror (off picture at lower left). He's about to plug the line into the black distributing box, shown on the catwalk between his feet, half hidden by the air-lock tower.

The sphere will be home to the voyagers not only for the five-day trip, but for several days after, while lunar quarters are being constructed. ▲▲▲

ILLUSTRATED BY FRED FREEMAN





Landing on the moon. Ten minutes before touchdown, rocket motors are switched on to slow down ships' high-speed fall caused by the moon's gravity. Vehicles are maneuvering 550 miles above landing area known as *Sinus Roris* (Dewy Bay), dark plain above cargo ship in lower left

blue of the oceans. Patches of white cloud obscure some of the detail; other white blobs are snow and ice on mountain ranges and polar areas.

Against the blackness of the earth's night side is a gleaming spot—the space station, reflecting the light of the sun.

Two hours and 54 minutes after departure, we are 17,750 miles from the earth's surface. Our speed has dropped sharply, to 10,500 miles an hour. Five hours and eight minutes en route, the earth is 32,950 miles away, and our speed is 8,000 miles an hour; after 20 hours, we're 132,000 miles from the earth, traveling at 4,300 miles an hour.

On this first day, we discard the empty departure tanks. Engineers in protective suits step outside the cabin, stand for a moment in space, then make their way down the girders to the big spheres. They pump any remaining propellant into reserve tanks, disconnect the useless containers, and give them a gentle shove. For a while the tanks drift along beside us; soon they float out of sight. Eventually they will crash on the moon.

There is no hazard for the engineers in this operation. As a precaution, they were secured to the ship by safety lines, but they could probably have done as well without them. There is no air in space to blow them away.

That's just one of the peculiarities of space to which we must adapt ourselves. Lacking a natural sequence of night and day, we live by an arbitrary time schedule. Because nothing has weight, cooking and eating are special problems. Kitchen utensils have magnetic strips or clamps so they won't float away. The heating of food is done on electronic ranges. They have many advantages: they're clean, easy to operate, and their short-wave rays don't burn up precious oxygen.

Difficulties of Dining in Space

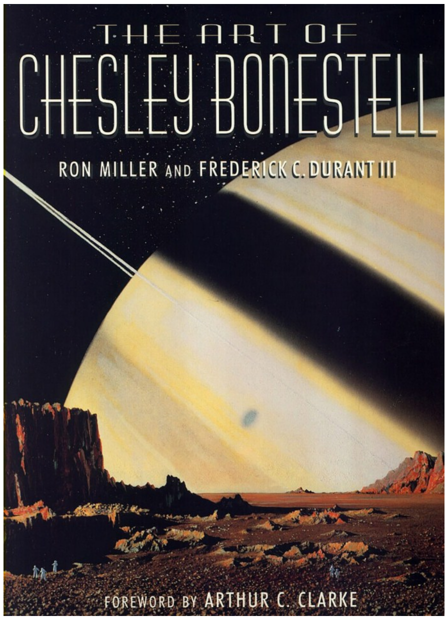
We have no knives, spoons or forks. All solid food is precut; all liquids are served in plastic bottles and forced directly into the mouth by squeezing. Our mess kits have spring-operated covers; our only eating utensils are tonglike devices; if we open the covers carefully, we can grab a mouthful of food without getting it all over the cabin.

From the start of the trip, the ship's crew has been maintaining a round-the-clock schedule, standing eight-hour watches. Captains, navigators and radiomen spend most of their time checking and rechecking our flight track, ready to start up the rockets for a change in course if an error turns up. Technicians back up this operation with reports from the complex and delicate "electronic brains"—computers, gyroscopes, switchboards and other instruments—on the control deck. Other specialists keep watch over the air-conditioning, temperature, pressure and oxygen systems.

But the busiest crew members are the maintenance engineers and their assistants, tireless men who have been bustling back and forth between ships since shortly after the voyage started, anxiously checking propellant tanks, tubing, rocket motors, turbopumps and all other vital equipment. Excessive heat could cause dangerous hairline cracks in the rocket motors; unexpectedly large meteors could smash through the thin bumpers surrounding the propellant tanks; fittings could come loose. The engineers have to be careful.

We are still slowing down. At the start of the fourth day, our speed has dropped to 800

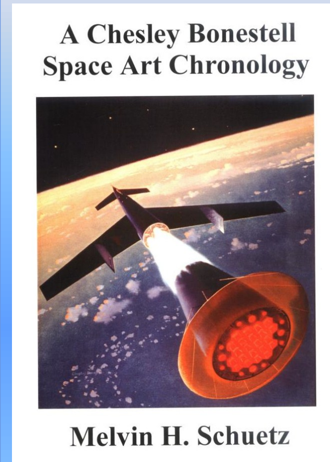
PAINTING BY CHESLEY BONESTELL



Award winner Ron Miller & Black Cat Studios

Ron Miller, winner of the 2002 Hugo Award (World Science Fiction Society) for Best Related Work: The Art of Chesley Bonestell

The Chesley Bonestell Archives of Melvin H. Schuetz



www.bonestell.com

A former satellite controller in the U.S. Air Force and private industry, Melvin H. Schuetz has researched and collected publications from around the world containing Bonestell's art for more than four decades. His book, A Chesley Bonestell Space Art Chronology, is a unique reference bibliography containing detailed listings of over 750 publications which have included examples of Bonestell's space art.

Space scientist and well-known author of visionary books on spaceflight. Ordway was in charge of space systems information at the Marshall Space Flight Center from 1960 to 1963 and before that performed a similar function for the Army Ballistic Missile Agency. For many years he was a professor at the University of Alabama's School of Graduate Studies and Research. However, his greatest contribution has been to the popularization of space travel through dozens of books that he has authored or coauthored. He was also technical consultant to the film 2001: A Space Odyssey and owns a large collection of original paintings depicting astronautical themes. Ordway was educated at Harvard and completed several years of graduate study at the University of Paris and other universities in Europe.

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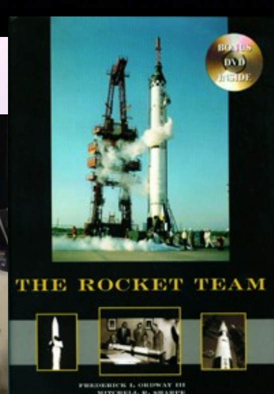


Frederick Ira Ordway III

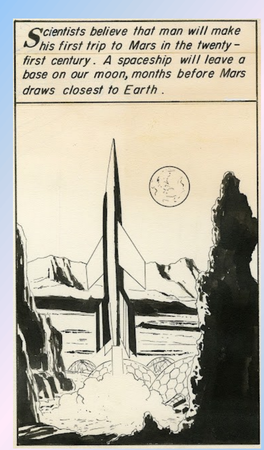
Co-Author with Mitchell R. Sharpe of The Rocket Team

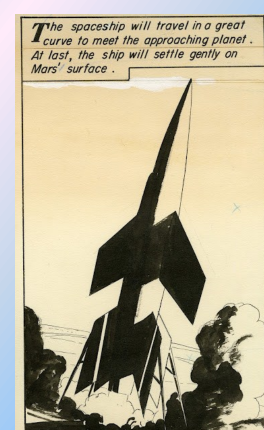
Dreams of Space, Books & Ephemera

Non-Fiction Children's Books about Space Flight from 1945 to 1975

http://dreamsofspace.blogspot.fr

Below: From John Sisson's Dreams of Space blog entry, this art is by Angelo Torres, from a 1961 non-fiction Classics Illustrated comic book, The World Around Us, Undersea Adventures #30.





APR Corner

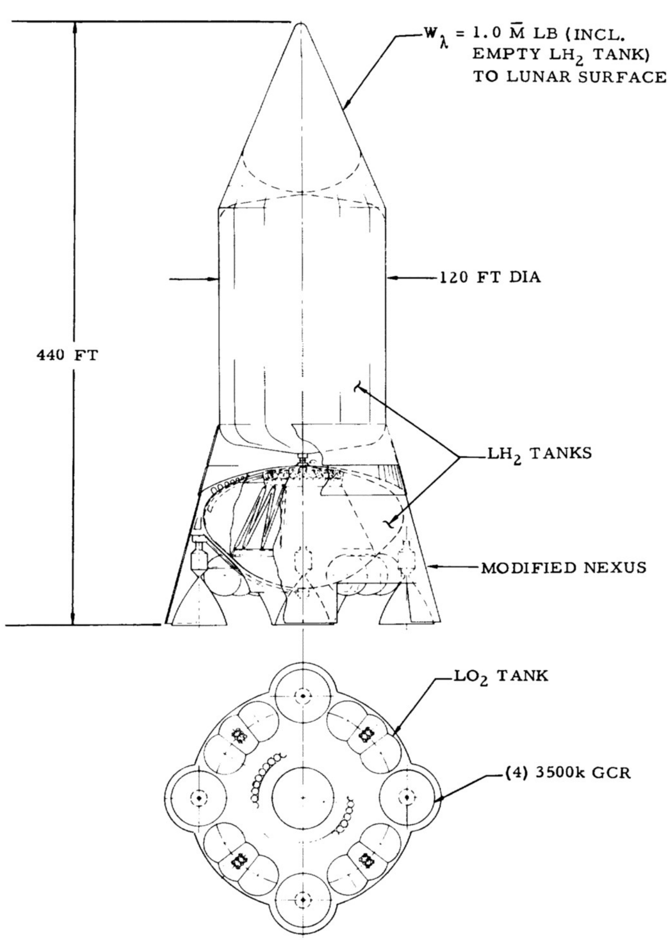
Aerospace Projects **Review**

Convair "Super-NEXUS"

SCOTT LOWTHER

The Convair "Super NEXUS" of 1963 was certainly one of the most ambitious and forward thinking launch vehicles ever contemplated by a serious aerospace corporation. Delivery of one million pounds of payload to the lunar surface would be possible with this vehicle, which was a modification of the NEXUS single-stage-to-orbit design. It would launch using conventional hydrogen-oxygen rocket engines on the NEXUS core; at a velocity of 8,000 feet per second four nuclear Gas Core Rockets (GCRs) would ignite and the chemical rockets burn out. The GCRs would put the vehicle into a circular Earth orbit for check-out, then ignite again for a 60-hour transfer orbit to the moon. Once there the vehicle would enter a circular orbit about the moon and then brake, completely cancelling out orbital velocity and dropping to a hover 1500 feet above the lunar surface. The payload, which would include the now-empty segmented

(Continued on page 49)



Above: Design P/S-E-LV 3.5, the "Super NEXUS." (Convair) Image credit: Scott Lowhter.

miles an hour, only slightly more than the speed of a conventional jet fighter. Ahead, the harsh surface features of the moon are clearly outlined. Behind, the blue-green ball of the earth appears to be barely a yard in diameter.

Our fleet of unpowered rocket ships is now passing the neutral point between the gravitational fields of the earth and the moon. Our momentum has dropped off to almost nothing—yet we're about to pick up speed. For now we begin falling toward the moon, about 23,600 miles away. With no atmosphere to slow us, we'll smash into the moon at 6,000 miles an hour unless we do something about it.

Rotating the Moon Ship

This is what we do: aboard each ship, near its center of gravity, is a positioning device consisting of three flywheels set at right angles to one another and operated by electric motors. One of the wheels heads in the same direction as our flight path—in other words, along the longitudinal axis of the vehicle, like the rear wheels of a car. Another parallels the latitudinal axis, like the steering wheel of an ocean vessel. The third lies along the horizontal axis, like the rear steering wheel of a hook-and-ladder truck. If we start any one of the wheels spinning, it causes our rocket ship to turn slowly in the other direction (pilots know this "torque" effect; as increased power causes a plane's propeller to spin more rapidly in one direction, the pilot has to fight his controls to keep the plane from rolling in the other direction).

The captain of our space ship orders the longitudinal flywheel set in motion. Slowly our craft begins to cartwheel; when it has turned half a revolution, it stops. We are going toward the moon tail-end-first, a position which will enable us to brake our fall with our rocket motors when the right time comes.

Tension increases aboard the three ships. The landing is tricky—so tricky that it will be done entirely by automatic pilot, to diminish the possibility of human error. Our scientists compute our rate of descent, the spot at which we expect to strike, the speed and direction of the moon (it's traveling at 2,280 miles an hour at right angles to our path). These and other essential statistics are fed into a tape. The tape, based on the same principle as the player-piano roll and the automatic business-machine card, will control the automatic pilot. (Actually, a number of tapes intended to provide for all eventualities will be fixed up long before the flight, but last-minute checks are necessary to see which tape to use—and to see whether a manual correction of our course is required before the autopilot takes over.)

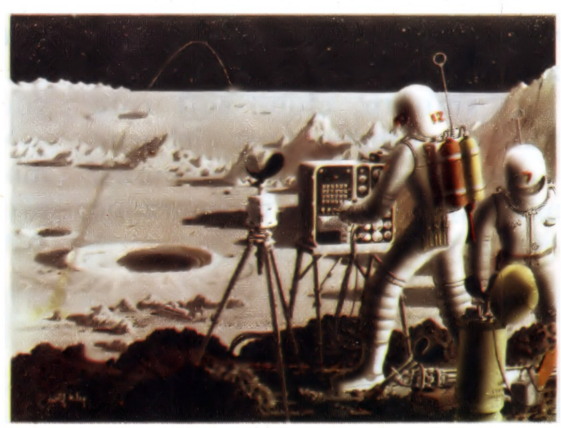
Now we lower part of our landing gear—four spiderlike legs, hinged to the square rocket assembly, which have been folded against the framework.

As we near the end of our trip, the gravity of the moon, which is still to one side of us, begins to pull us off our elliptical course, and we turn the ship to conform to this change of direction. At an altitude of 550 miles, the rocket motors begin firing; we feel the shock of their blasts inside the personnel sphere and suddenly our weight returns. Objects which have not been secured beforehand tumble to the floor. The force of the rocket motors is such that we have about one third our normal earth weight.

The final 10 minutes are especially tense. The tape-guided automatic pilots are now in full control. We fall more and more slowly, floating over the landing area like descending helicopters. As we approach, the fifth leg of our landing gear—a big telescopic shock absorber which has been housed in the center of the rocket assembly—is lowered through the fiery blast of the motors. The long green rocket flames begin to splash against the baked lunar surface. Swirling clouds of brown-gray dust are thrown out sideways; they settle immediately, instead of hanging in air, as they would on the earth.

The broad round shoe of the telescopic landing leg digs into the soft volcanic ground. If it strikes too hard, an electronic mechanism inside it immediately calls on the rocket motors for more power to cushion the blow. For a few seconds, we balance on the single leg. Then the four outrigger legs slide out to help support the weight of the ship, and are locked into position. The whirring of machinery dies away. There is absolute silence. We have reached the moon.

Now we shall explore it.



NEXT WEEK

The Exploration of the Moon

MAN on the MOON

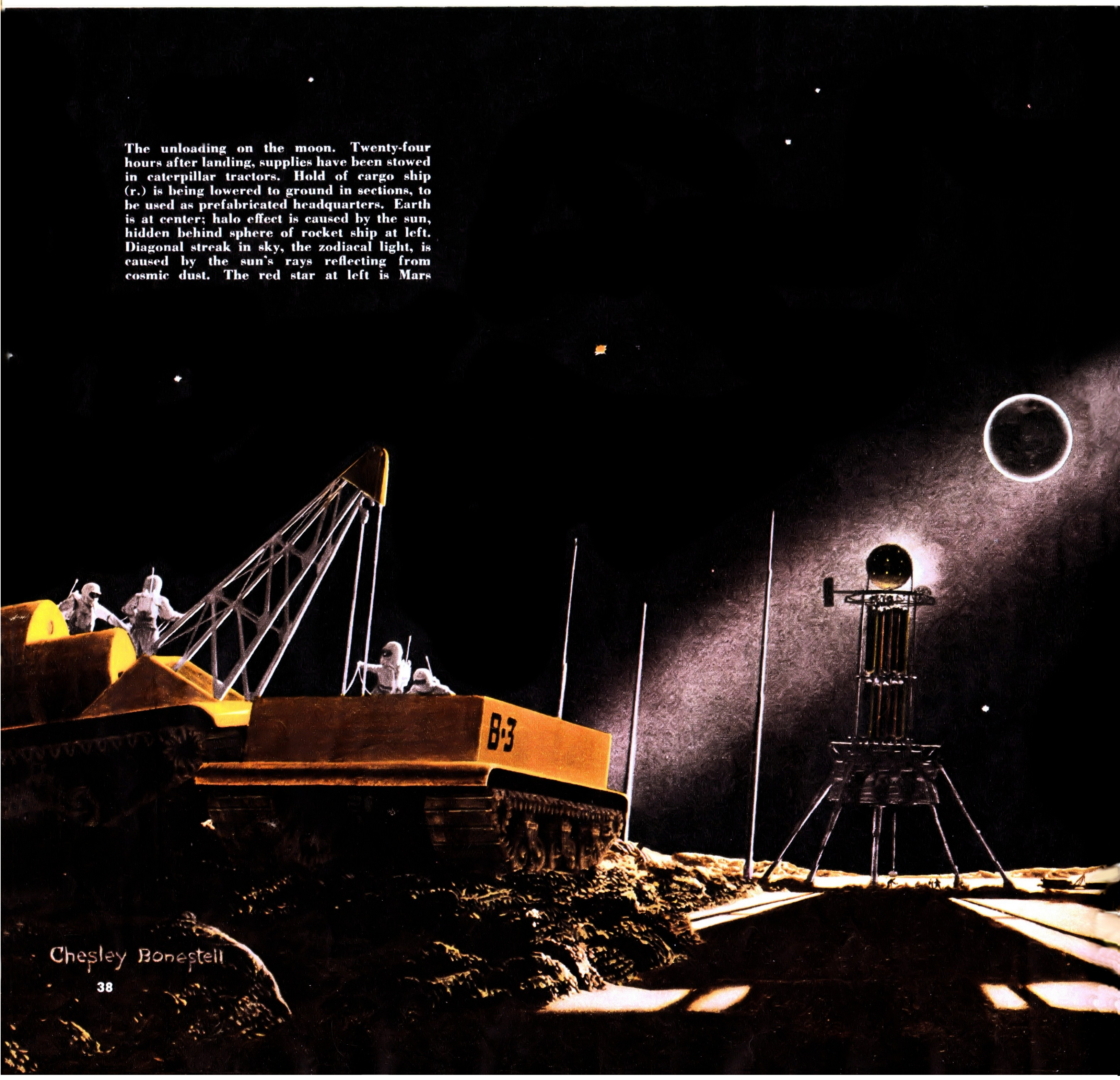
THE EXPLORATION

By DR. FRED L. WHIPPLE and DR. WERNHER von BRAUN

CHAIRMAN, DEPARTMENT OF ASTRONOMY, HARVARD UNIVERSITY

TECHNICAL DIRECTOR, ARMY ORDNANCE GUIDED MISSILES DEVELOPMENT GROUP, REDSTONE ARSENAL, HUNTSVILLE, ALABAMA

Our top scientists say we'll reach the moon in our lifetime. What do we find when we get there? What are the secrets of this ball of rock five times the size of the United States? Here's expert testimony



The unloading on the moon. Twenty-four hours after landing, supplies have been stowed in caterpillar tractors. Hold of cargo ship (r.) is being lowered to ground in sections, to be used as prefabricated headquarters. Earth is at center; halo effect is caused by the sun, hidden behind sphere of rocket ship at left. Diagonal streak in sky, the zodiacal light, is caused by the sun's rays reflecting from cosmic dust. The red star at left is Mars

THERE is danger on the moon—the danger of the unknown. Our first expedition, which can land there in the next 25 years, must be prepared. Tissue-damaging cosmic rays—invisible, deep-penetrating atom particles—unpredictably streak in from space, with no atmosphere to impede them. Meteorites, from microscopic grains to mountainous boulders, hurtle down. On the lunar surface, thin layers of crust might cover great crevasses, making travel perilous. Jagged rocks threaten the fabric of the pressurized, oxygen-equipped space suits essential to life.

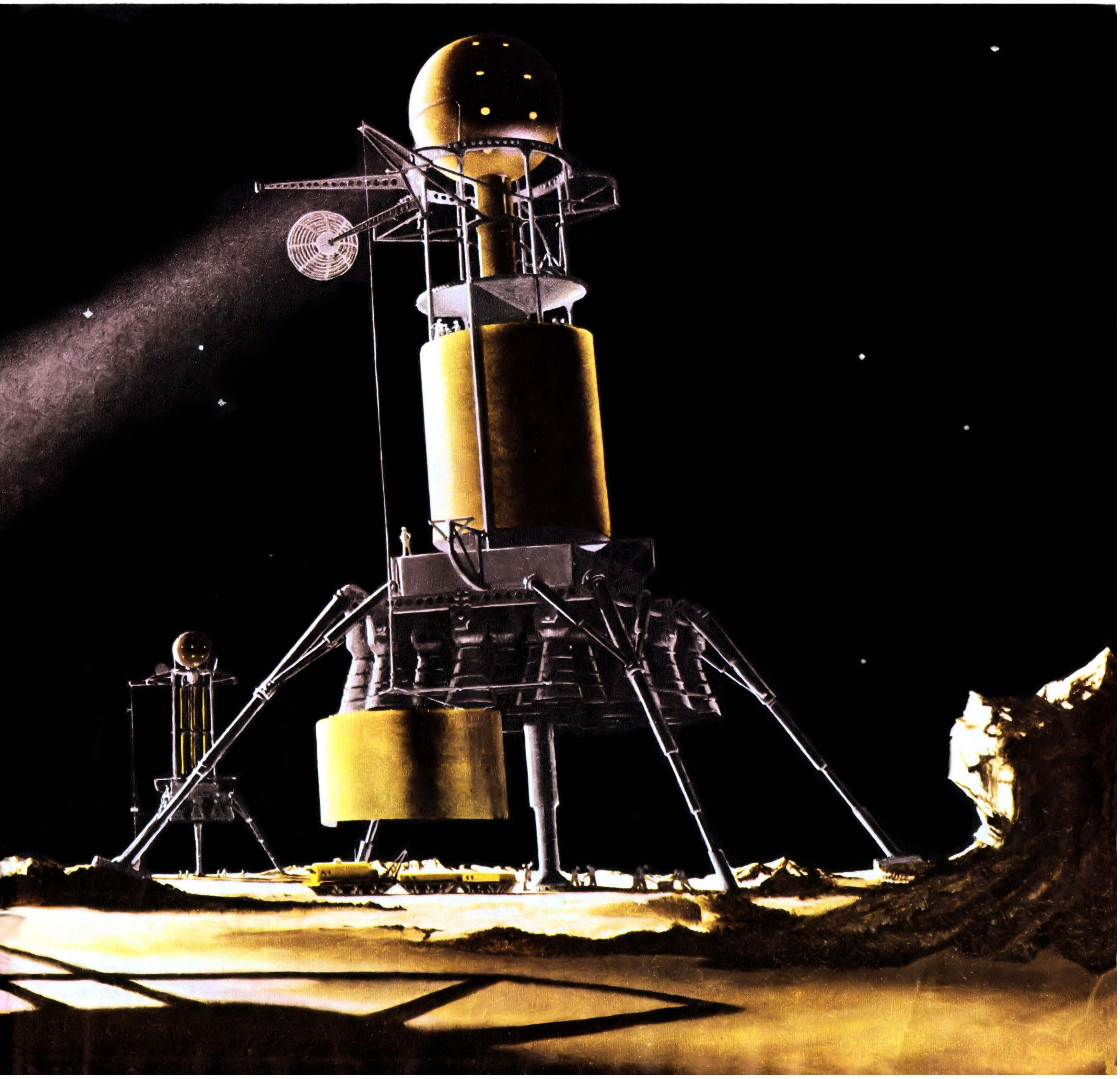
How great are the hazards? We don't know exactly, but we do know how to take precautions. Until we can measure the severity of the cosmic radiation, we shall stay under cover as much as possible. Our headquarters must be located in a deep crack in the surface, protected from both rays and meteorites. Brief exposure to cosmic radiation probably won't hurt us. Exposure to large meteorites will hurt us—but we don't expect to encounter them; the smaller meteorites will shatter against the two thicknesses of our space suits. The keen eyes of experienced geologists will guard us against break-throughs in the crust. Caution should be ample protection against rips in the precious space suits. We can explore the moon safely.

Our first step after arrival is to unload equipment and prepare for a six-week stay. Three awkward-looking but efficient rocket ships (none of them streamlined, because there is no air resistance in space) have carried us to the lunar surface from a man-made satellite 1,075 miles above the earth. On this voyage, two of the craft carried passengers and propellant for a return trip; the third, a one-way cargo vehicle, must be dismantled and converted into living and working quarters for the 50-man expedition.

We have arrived just at the beginning of the two weeks of sunlight that comprise the lunar day. From the catwalks of the ships, 130 feet above the moon's surface, the scene is dismal. The pitted surface of the landing area—a place known to scientists as *Sinus Roris,* or Dewy Bay, not far from the lunar north pole—stretches to the south like a vast, discolored expanse of broken ice.

On the other three sides, we are surrounded by towering mountains. The rays of the rising sun

CHESLEY BONESTELL



have painted the great mountain range a blinding white against the pitch blackness of the sky. But elsewhere, there is none of the brilliant color we are used to on earth—just dull, lifeless browns and grays. There is no cloud cover, no wind, no rain or snow—no weather of any kind. Overhead, pinpoint stars shine steadily; they don't twinkle, for there is no blurring atmosphere, as on earth.

Dust-covered, drab, silent, the panorama has the frozen stillness of a faded backdrop.

Within minutes after the landing, big cranes on the sides of the passenger ships swing out and start lowering expedition members to the ground. In our cumbersome space suits, we plod through the quarter-inch dust layer toward the cargo ship, whose crewmen are already starting the unloading operation. Our movements are restricted by the suits, yet we feel light. The moon's gravity is about one sixth that of the earth; a 180-pound man weighs only 30 pounds now. We wear weighted shoes to help pin us down.

The first equipment brought out of the cargo ship is one of our three surface vehicles, tanklike cars equipped with caterpillar treads for mobility over the moon's rough surface. The pressurized, cylindrical cabins hold seven men, two-way radio equipment, radar for measuring distances and depths, and a 12-hour supply of oxygen, food, water and fuel. Power is provided by an enclosed turbine driven by a combination of hydrogen peroxide and fuel oil (oxygen escaping from the hydrogen peroxide enables the fuel oil to ignite). The vehicle goes 25 miles an hour on flat ground.

As soon as the moon car has been set down and checked, a search party boards it to scout out a suitable crevice for the campsite. They drive off in a spray of dust which settles almost immediately, like the bow wave of a motorboat (there is no air to hold the dust suspended, as on earth).

The area around the cargo ship bustles with activity. Through our earphones, we can hear a stream of orders from the engineer in charge of unloading. All orders are addressed to numbers, rather than names; faces are not visible through the heavy antiglare glass of the helmets, and we wear numerals for identification.

By the time the search party returns, the ground around the cargo ship is littered with supplies: containers of water and liquid oxygen, canned and frozen food, scientific equipment, high explosives, rockets, the other two lunar cars and nine trailers (three per car) also track-equipped.

Ship's Hold Is Converted into Huts

In all, the huge cylindrical cargo hold, 75 feet long and 36 wide, has held 285 tons of supplies (less than 50 tons, moon-weight). But the silolike hold is itself part of the cargo, and must be unloaded from the framework of the ship. Its walls are laced with wiring, air-conditioning ducts, and water and sewage pipes; split lengthwise, the cargo cabin will become two buildings like Quonset huts, and the horizontal floors which separated it into compartments will be vertical partitions. We'll live in one hut; the other will be a laboratory.

Engineers direct the unbolting of the hold from the framework, and cranes lower the huge cylinder in sections onto trailers. Two of the lunar tractors hitch up to three trailers each, and the double convoy moves silently off for the headquarters site. A third convoy, loaded with supplies and personnel, brings up the rear.

The framework of the cargo ship now stands stripped and forlorn on the barren plain, only its personnel sphere left intact. We'll leave it there and use the sphere, with its expensive radio equipment and big disk antenna, as a station for communication with the earth—lonely, but essential, duty for the radio operators.

The crevice picked for the campsite by our search party is deep—we require a depth of 65 to 100 feet for safety—with almost vertical sides. Cranes attached to the rear of the lunar tractors lower an advance squad to the floor of the chasm. It's fairly level down there, but some big chunks of rock may have to be moved to clear the way for the two prefabricated huts; pickaxes and small explosive charges do most of the work, and the cranes do the rest. Now the sections are lowered.

The front ends of the tractors are firmly anchored to the moon's surface, and one by one the hut units are eased down the side of the gully. They are quickly assembled at the bottom; electrical circuits are joined, air conditioning, water and sewage pipes hooked up—and we're ready to move in. A power unit like those on the rocket ships—a solar mirror which heats mercury to produce vapor (like steam) for a turbogenerator—is set up at the lip of the chasm.

We have now been on the moon 48 hours. There has been little sleep for anybody, but the preparatory work is over. Supplies (including our store of high explosives) are now safely out of the way of vagrant meteorites; our living quarters and laboratory are ready to use—and we'll be ready to explore as soon as we've slept.

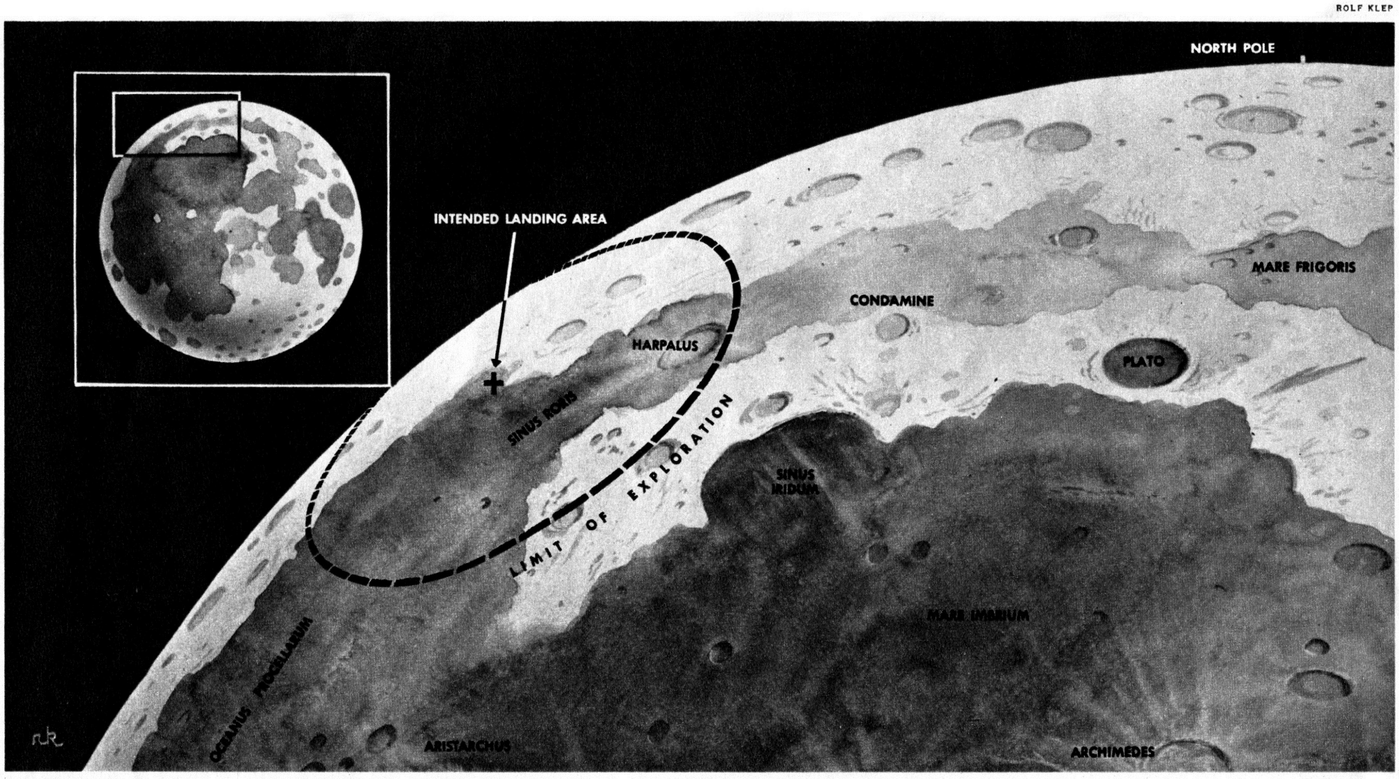
Sinus Roris, our landing area, was selected partly because of the opportunities it offers for exploration, partly because its temperature is livable—40 degrees Fahrenheit during the lunar daytime (at the lunar equator it hits a blistering 220 degrees), and 240 degrees below zero at night. That's mighty cold, but it's bearable on the airless, waterless moon, and we have heaters inside the huts.

From our headquarters site, we can explore any place within a range of 250 miles, and all the lunar features of interest to our scientists fall within that area. It may require some long trips, though—the region involved is approximately as large as the whole northeastern part of the United States, north of Washington, D.C.; in other words, the size of the six New England states, New York, Pennsylvania, New Jersey, Maryland and Delaware. Besides looking over selected sites on the side of the moon visible from the earth, we'll also be able to see a part of the unknown side—the part always turned away from the earth.

What will we be looking for?

To start with, our scientists want to know whether any faint traces of atmosphere are present, what minerals there are (maybe we'll find some rare, useful ones), whether the moon has a magnetic field like the earth and how the temperature varies beneath the lunar crust. Sheer curiosity suggests other questions and will play a large part in our explorations. We're the first people who've ever been here, the first ever to peer into the mys-

ROLF KLEP



Exploration area, within dotted line, covers 195,000 square miles, about equal to New England, New York, New Jersey, Maryland, Pennsylvania, Delaware. It lies in lunar northern hemisphere and can be seen by naked eye from earth at full moon (see inset, left)

Hubble Meets Skylab

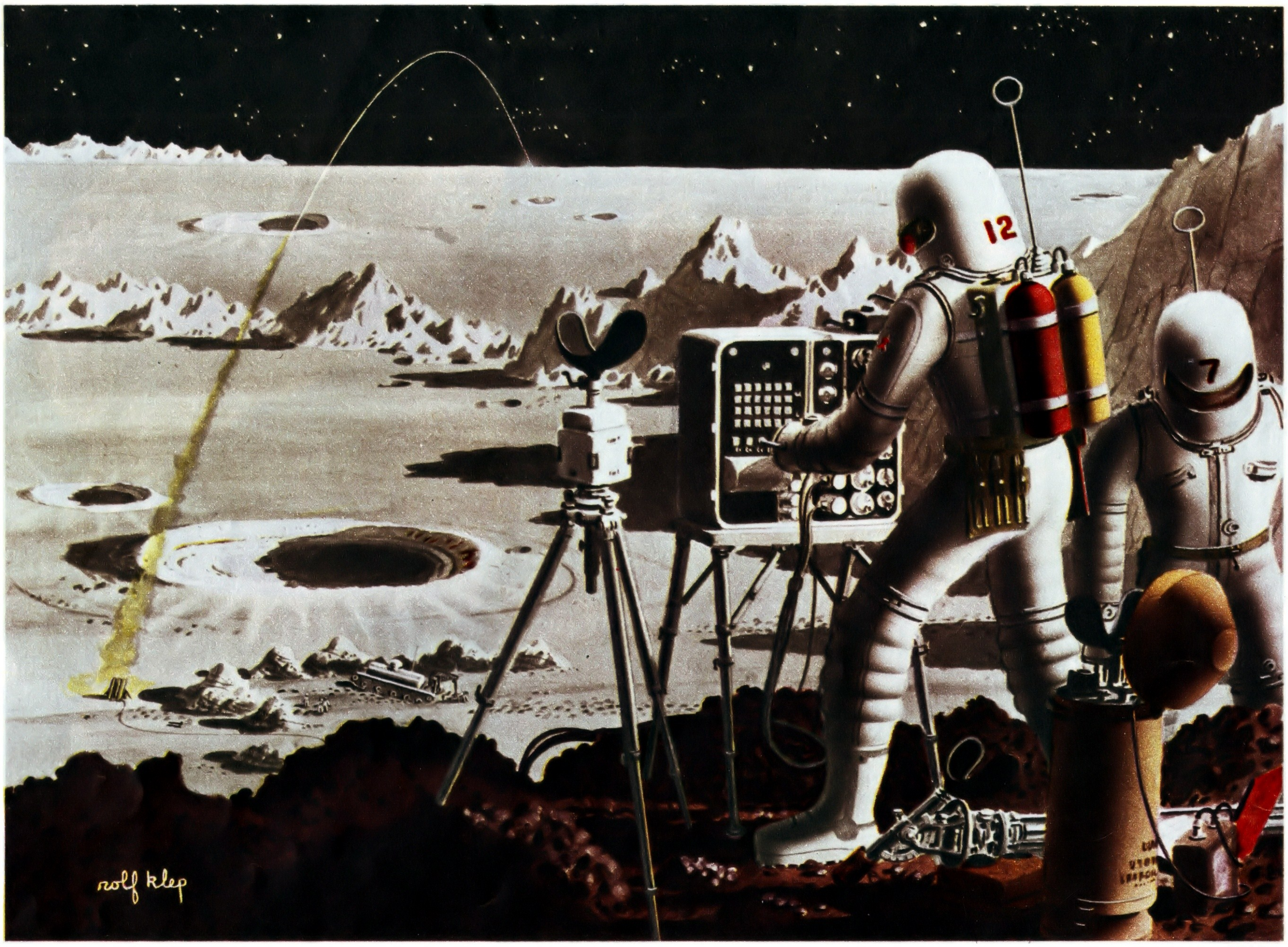
SCOTT LOWTHER, AEROSPACE PROJECTS REVIEW

A number of apparently completely independent space projects have been linked, even if only briefly. Two such programs were Skylab and the Hubble Space Telescope. For a brief period in 1970, there was work on joining the two together.

The idea for a large orbital astronomical telescope originated in the late 1960s as a logical outgrowth of the ongoing growth in orbital telescopes, both astronomical and military. Until well into the 1970's, the only effective ways to return telescope imagery to the surface was via television (which produces grainy low-resolution images in real-time) or via film (which produces high quality images, but very slowly). Since astronomical satellite telescopes have a much greater need of high quality pictures than fast images, large space telescope designs of the late 60's and early 70's tended to utilize film. A number of spy satellites used film that would be dropped to Earth by way of small capsules, but this entailed considerable risk of loss and limited the total

(Continued on page 70)

Aerospace Projects **Review**



ROLF KLEP

terious lunar valleys, the first to examine the mountains and craters of the moon close up. Who knows what we may find on this virgin ball of unexplored rock, about five times the size of the United States?

The possibilities are exciting. Suppose we turn up a great store of raw materials; maybe then we'll want to recommend setting up a permanent community. We can make it practically self-supporting, securely encased inside a great plastic dome with its own synthetic atmosphere. Such an establishment could serve as a superb scientific laboratory—especially for astronomy and for research work requiring a vacuum; as a springboard for further ventures into space (if we can manufacture our own fuel on the moon, which is a possibility, we can make tremendous savings in the launching of a space ship); perhaps as a military base (the moon would be fine for launching military rockets, but hard to hit from the earth).

But the principal aim of our expedition during this first lunar exploration will be strictly scientific—and very important. Our investigations will help us unravel the secret of the universe: how the moons and planets were born and what they're made of. Up to now, all our information on that subject has come from examination of the earth and from surveying the heavens from observatories. The moon will give us a new perspective: a different look at the astral bodies and the story of its own birth as a clue to the birth of other satellites, planets and stars.

We know that the moon didn't form in the Pacific Ocean and get hurled into space, as was generally believed 50 years ago. It *is* possible that it was an independent planet which came from outer space, fell into the earth's gravitational field, smashed into the Pacific and then ricocheted back into its present orbit. But the most likely explanation is that the moon originally consisted of a belt of gases and minerals that girdled the earth—much as Saturn's ring surrounds that planet today—and eventually fused into a solid mass.

That's the theory we'll check.

First, if there are faint traces of such heavy gases as xenon and krypton, we'll know the moon was never a completely molten, hot mass (for extreme heat would have dispelled *all* gases), and so could not have been an independent planet. We'll find out by using a rotary pump which will compress whatever gases may exist and capture them in a bottlelike container. It probably will take many days to accumulate enough of whatever gases there may be, but checking them will be fairly simple.

Does the Moon Have an Iron Core?

Then we'll look for a magnetic field. If we don't find it, we'll have another indication that the moon doesn't have an iron core, as an independent planet would. Compasslike magnetometers will do the trick for us; if the moon has magnetic poles as the earth has, they will show up (isolated iron deposits also will register, but they will be easily distinguishable from a core).

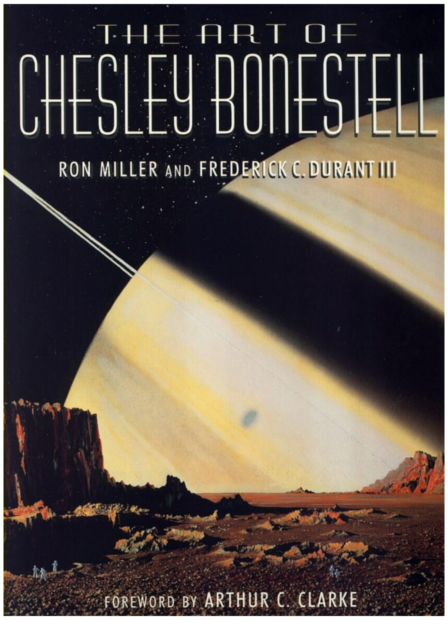
We'll also shake up the moon's surface a bit. Scientists have learned a lot about the earth from earthquakes. The vibration waves of a quake travel freely through solids, but some of them cannot pass through liquids—which is how we know that the center of the earth is molten iron. We can't count on having moonquakes, so we'll make some: we'll send off rockets with high-explosive war heads and

Causing moonquakes. Rockets with explosive war heads are fired off and scientists check vibration waves caused by distant blast, to determine interior composition of the moon. Seismograph in foreground is push-button controlled and surveying instrument to its left has cupped headpiece, to accommodate hand hooks and helmets of expedition members

then read the story of the waves from our seismographs. The explosions, occurring about 100 miles away, will show if the moon's core is molten (in which case, our waves will be stopped), solid (they'll go right through), or a jumble of rocks which never have been molten (muffled waves).

There is another clue to the moon's origin: the scars on its surface. The plains of the moon are rough and scored by fissures. Close examination will disclose whether these score marks are cracks or wrinkles. Wrinkles will indicate that the moon was molten at birth, and has cooled since. Cracks will be evidence that it was cool to begin with and has since been heated, perhaps by radioactivity. Fortunately, these lunar birthmarks have not been washed away by erosion, as has happened on earth.

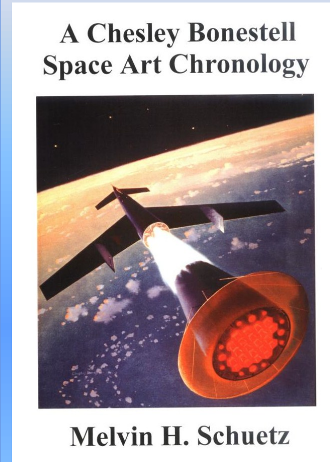
So much for the moon's past. There are also some facts we want to learn about its present. One of the most important is the exact intensity of the cosmic rays which strike it. As soon as we're settled in our quarters, we set out instruments to measure the rays. Another is the frequency of meteorite hits. Careful measurements also will be kept of the surface temperature caused by the sun, and we'll want to measure the subsurface tempera-



Award winner Ron Miller & Black Cat Studios

Ron Miller, winner of the 2002 Hugo Award (World Science Fiction Society) for Best Related Work: The Art of Chesley Bonestell

The Chesley Bonestell Archives of Melvin H. Schuetz



www.bonestell.com

A former satellite controller in the U.S. Air Force and private industry, Melvin H. Schuetz has researched and collected publications from around the world containing Bonestell's art for more than four decades. His book, A Chesley Bonestell Space Art Chronology, is a unique reference bibliography containing detailed listings of over 750 publications which have included examples of Bonestell's space art.

Space scientist and well-known author of visionary books on spaceflight. Ordway was in charge of space systems information at the Marshall Space Flight Center from 1960 to 1963 and before that performed a similar function for the Army Ballistic Missile Agency. For many years he was a professor at the University of Alabama's School of Graduate Studies and Research. However, his greatest contribution has been to the popularization of space travel through dozens of books that he has authored or coauthored. He was also technical consultant to the film 2001: A Space Odyssey and owns a large collection of original paintings depicting astronautical themes. Ordway was educated at Harvard and completed several years of graduate study at the University of Paris and other universities in Europe.

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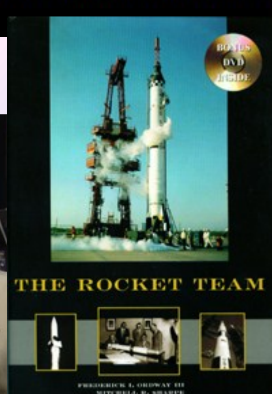


Frederick Ira Ordway III

Co-Author with Mitchell R. Sharpe of The Rocket Team

Dreams of Space, Books & Ephemera

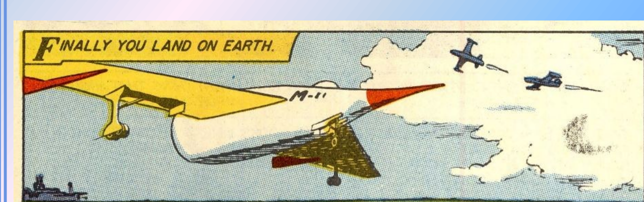
Non-Fiction Children's Books about Space Flight from 1945 to 1975

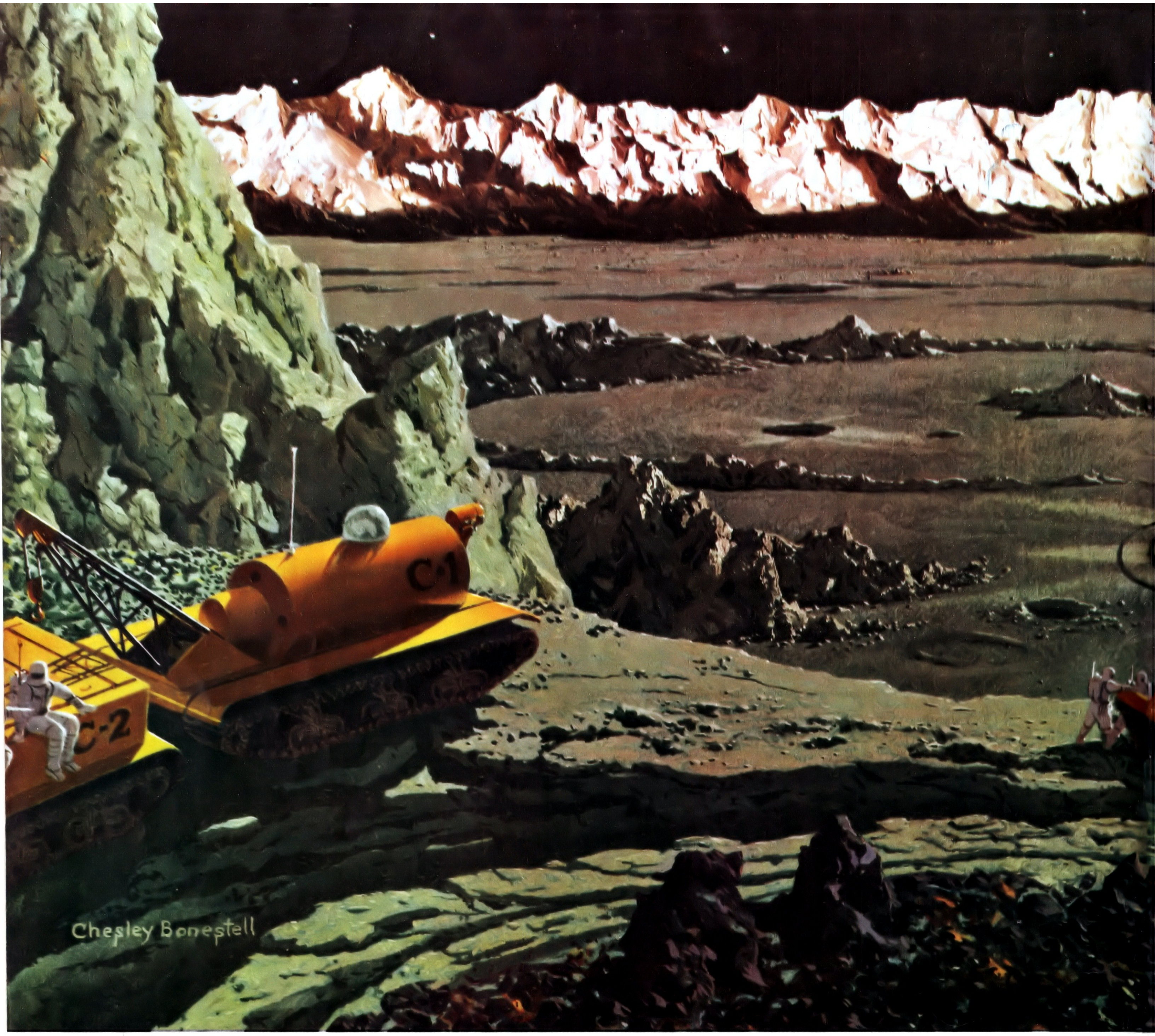
http://dreamsofspace.blogspot.fr

Classics Illustrated were comic books intended to educate as well as entertain. They often were fictional "classic" books in comic book form such as Moby Dick. They also had a special series called "The World around Us." These were non-fiction comic books about topics of interest.

Classics Illustrated. Illustrated by Gerald McCann, Sam Glanzman and John Tartaglione. The Illustrated Story of Space (80 pages), 26 cm, softcover.

Contains illustrated stories on training for space, the first rocket to the Moon, the history and use of the rocket, the launch of Vanguard 1 and the construction of a space station. "The World Around Us" (#5) January 1959.





At end of two-week-long lunar day, convoy of tractors, each pulling two of its three trailers, moves cautiously across rough terrain near plain

ture at varying depths (it may be considerably warmer than the surface, due to radioactivity).

For two weeks, we devote ourselves to research on these points, past and present. The expedition breaks up into teams, each with its own assignment. Most of the investigating during this period is done within a 10-mile radius of the base. It's difficult, dangerous work. We climb across meteor pits, into chasms, up great rock piles, struggling in our bulky suits, always fearful of snagging ourselves on sharp outcroppings, always nervous about stray meteorites and watchful for thin crust.

Because we'll never be really certain how safe we are on the moon, however long we stay, we keep up a chatter over our walkie-talkie radio transmitters, not to bolster our courage, but for a practical reason: if something happens to us, the people back at headquarters will have a record of our findings.

For the same reason, lunar headquarters maintains constant contact with the earth. Back there, a special panel of scientists remains in constant session, as it will all during our six-week stay. A dozen specialists in fields like astronomy, astrophysics, geophysics, mineralogy and geology follow our every move by radio (as, indeed, does the entire world), keeping track of our findings, suggesting new leads and occasionally asking for the repetition of an experiment. Television transmission is impractical, but every day dozens of photographs are radioed back to earth.

For those of us on the moon, the work is endless and fascinating. We collect samples of everything in sight—dust (where did it come from; what's it composed of?), mineral specimens, rock and lava fragments. Besides scouring the lunar surface, we make test drillings several hundred feet into the moon's ground, and collect more samples that way.

We work in almost frantic haste during these two weeks, trying to make the most of the brilliant sunlight. We eat and sleep in shifts, so that there will be no halt in the research, no break in the flow of information back to the earth.

But soon the sun begins to slip over the horizon. For a while, there's still plenty of light; work slows down, but not entirely. For several days after sunset, we live in a kind of twilight, with a cold, but fairly bright, illumination cast over us by the earth (it reflects about 60 times as much sunlight on the moon as the full moon reflects on the earth). The browns and grays of the lunar day take on a green tint; mountains throw long shadows; craters and chasms appear jet black. The light grows dimmer as the "full earth" becomes a "half earth."

Now comes an exciting moment: the start of our longest expedition. We've had to wait to make it, because all the vehicles have been in constant use for the vital explorations near the base; as a result, we'll have to travel outbound in comparative darkness. That's not desirable, but it's possible, and we have no alternative.

of *Sinus Roris* (Dewy Bay). Glare of mountain range to north is caused by setting sun. Remainder of scene is illuminated by greenish earth light

Our destination is a crater about 195 miles away as the rocket flies, but about 250 miles off by lunar tractor. This crater, called Harpalus, is the most interesting one within reach—24 miles across, with a surrounding ridge 3,100 feet high, and a depth of almost 11,000 feet from peak to bottom.

It must have taken a monstrous meteorite to smash into the moon with such force—or was it a meteorite? That's one of the questions we want answered. All we know before we start is that a meteorite *could* make such a crater—if it were the size of a small mountain, and traveling at a speed of thousands of miles an hour. Another mystery we can solve on this journey is the nature of the great white marks which radiate for tremendous distances from the most perfect (and perhaps the newest) craters. Maybe they're powdered dust, shot out by the impact of meteorite against moon; maybe their origin is volcanic. We'll soon know.

Our expedition consists of two tractors, hauling three trailers each. Ten men are making the trip, and we carry supplies and fuel enough to last about two weeks. The outbound trip should take a little less than five days, the return journey, made in sunlight, perhaps four; we also want to spend a day or two at the crater. That's 10 days. We carry an extra four days' emergency supplies.

The trip is slow and difficult. The two vehicles cautiously pick their way around great rocks and deep pits, making about two miles an hour over the rough ground. Powerful searchlights and radar probe for major obstacles; at suspicious places, a geologist hops out to scan the ground for thin crust and feel his way afoot. When, despite our precautions, one of the tractors gets stuck in a rut, the other hauls it out.

At selected points along our course, we stop and plant explosives—part of our vibration-wave experimentation—which technicians back at headquarters will fire later by remote control (the explosions will be visible from the earth through strong telescopes).

After four days, the perimeter ridge of Harpalus looms ahead. As we press on, the first rays of the sun—marking our second lunar day on the satellite—glare off the side of the ridge and the mountain range to our left. By the time we get to the base of the ridge, full sunlight pours down on us again.

From a few miles away, the crater rim is measured with surveying instruments and photographed with special cameras. As we move closer, lava samples are collected, and holes are drilled for additional specimens. Other members of the expedition take temperature readings, check for magnetism and gather dust specimens.

Scaling the crater wall is a hard job. In some places, where the ridge is rough, we can make slow progress with regular mountain-climbing equipment; elsewhere, steep walls compel us to shoot grappling hooks up the sides by means of rockets;

PAINTING BY CHESLEY BONESTELL

rope ladders then enable us to reach the rim. The party descends as far as it can into the mouth of the crater. When no further progress is possible, we lower one man by rope to examine the floor and gather lava specimens. It's tricky, dangerous work; despite the relatively slight gravitational pull, a tumble would be just as dangerous as on earth, for there's no atmosphere to retard a falling body.

We work swiftly, for our time is limited. After a day or two at the crater, we start back, making a detour to examine the mountain range to the northeast, where there are interesting rock and lava formations and cavelike holes of unknown origin. The trip home is faster than the journey to the crater; the vehicles are heavily laden with specimens, but there is light to drive by. In a few days, we're back at the headquarters crevice.

Now the six hectic weeks of exploration draw to a close. At the landing site, electronic engineers set up automatic recording instruments which will radio scientific observations to earth after we've taken off. These stations (not much larger than an office desk) house delicate instruments which record cosmic radiations, tremors caused by the impact of meteorites hitting the surface, temperature changes and other scientific data. They are connected by cables to the skeleton of the cargo ship, which we're leaving behind. The ship's solar mirror generates power for the instruments, and the dishlike antenna will flash the readings to earth. Unless these automatic stations are destroyed by meteorites, they will operate for years without human supervision.

Engineers and technicians clamber over the passenger ships, checking pumps, rocket motors and electrical connections. The day before take-off, specimens for later study, oxygen and any remaining food are loaded onto the trailers at the lunar base. The entrances to the two huts are left open, permitting the synthetic atmosphere to escape; all material in the living quarters and laboratory will now be preserved by the vacuum of space.

During the next few hours, the cranes of the two ships haul up supplies. Each lunar tractor, when finally unloaded, is parked beside the skeleton of the cargo ship, to remain until the next lunar expedition. At last the cranes complete the loading

INSIDE the LUNAR BASE

By WILLY LEY

NOTED ROCKET SCIENTIST AND AUTHOR

THE first visitors to the moon will travel 239,000 miles through space—and then go underground at their destination. For their six-week stay, their home will be in a deep chasm, for protection against meteorites and cosmic rays. The cylindrical hold of the cargo-carrying rocket ship is split into lengthwise halves, 75 feet long and 36 wide, and lowered in sections by the cranes of our lunar tractors. One of the halves becomes a laboratory; we live in the other.

In the picture at right, one tractor is seen at the lip of the crevasse, lowering scientific specimens from the surface. Expedition members may also use the crane to enter the chasm, or they may climb down the light extension ladder at the left. Between the ladder and the tractor is a power plant like those on the rocket ships: a solar mirror focuses the sun's rays on a mercury pipe, creating vapor which drives a turbogenerator.

Each of the two buildings has its own air-conditioning, oxygen and water-recovery systems (the latter captures and cleanses for re-use all the moisture in the synthetic atmosphere we have provided within the huts). The air-conditioning and water-recovery plants of the laboratory building (rear) are visible just behind the ladder, on the first floor. Next is the chemical analysis room, and, to its right, the photographic darkroom. The radio operator works in the compartment next door, keeping in constant touch with fieldworkers, and recording their reports on tape. (The tapes are passed on to the radio operator in the cargo ship for transmission to the earth.) The upper floor at this end of the building is used for supplies and water storage (note the cylindrical water tanks).

The central unit of the hut contains a two-story screen for viewing color photographs, slides and films made in the course of the scientific investigations. At the far side of the room is a physical laboratory; experiments to determine whether the moon has an atmosphere are made here, and mineral samples are checked for magnetism, radioactivity and so forth. The projection room is visible under the pipes; next to it, through the open door, is a small conference room. To the right of the conference room, behind the small ladder, is a dispensary. Records are kept on the balcony above it.

The entire right-hand section of the lab building is an entry chamber, with space suits suspended by pulleys overhead. To get in and out of the huts, we crawl through air locks. A man is shown entering the laboratory air lock; the spring-loaded outer hatch will clap shut behind him, and a twist of wheel will open the inner hatch. (The wheel can be seen in the air lock of the other building, through which a man is about to leave.)

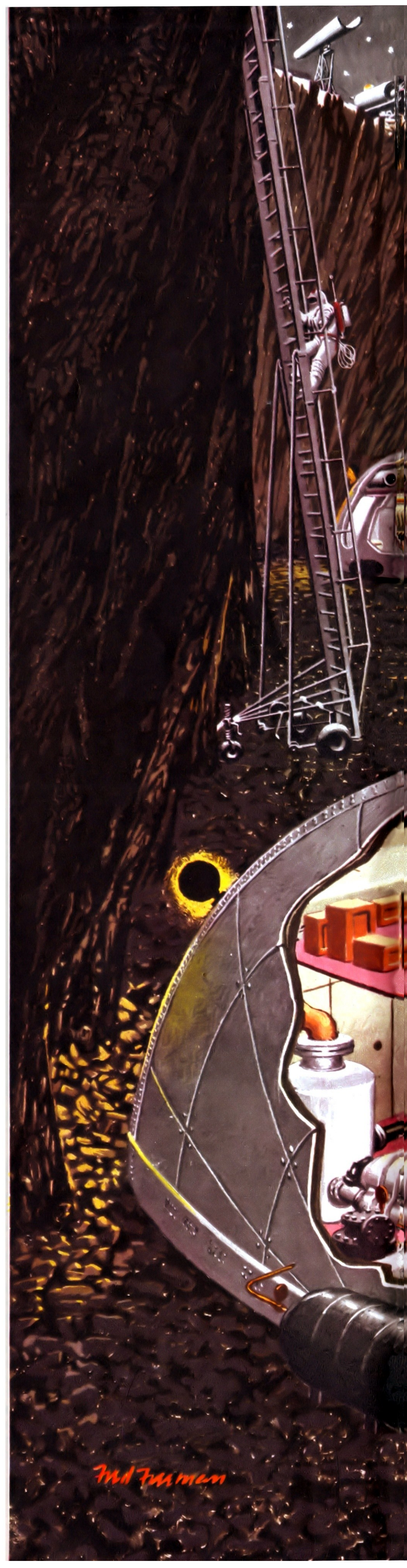
An airtight pipe connects the two huts; in an emergency, it can carry either water or air from one building to the other.

In the foreground of the hut used for living is a close-up view of the air-conditioning and water-recovery systems. The compartment behind it contains berths and lockers for most of the expedition members and, on the right, a washroom. (Bunks for the remaining personnel are on the second floor, which runs the length of the building and is otherwise used mainly for supplies.)

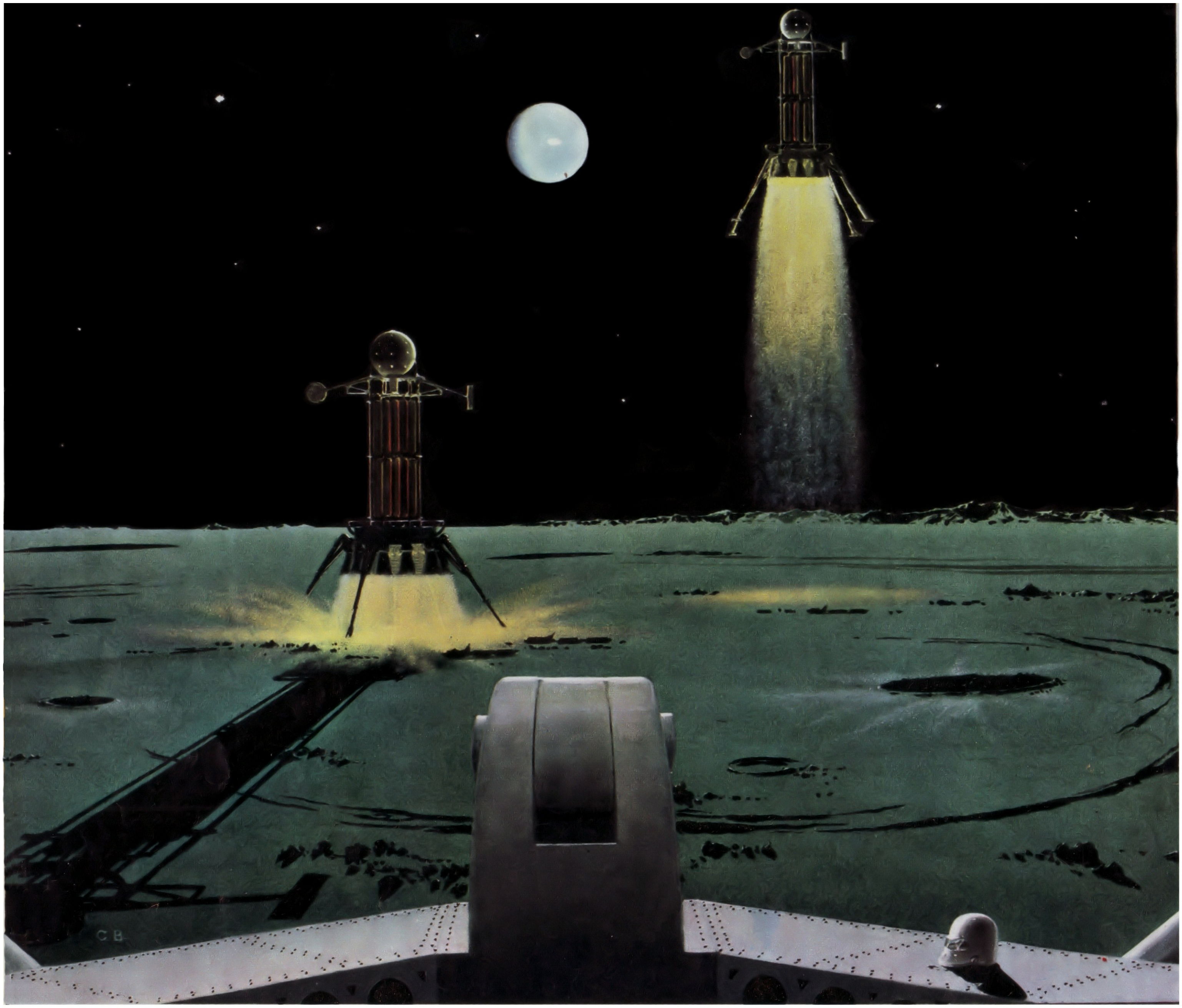
The large middle compartment has the expedition's kitchen and dining room. A dumb-waiter leads to the storehouse on the upper floor. The table-and-bench units in the dining area can be raised to the ceiling when not in use (one is shown in raised position). Against the right-hand wall of this section are washing machines, a hot-air drying room and a shower closet. The rearmost stalls on this wall are clothes lockers.

Oxygen supplies for both buildings are contained in the cylinders shown on the outside walls of the huts (they're placed there to save space). Also on the outer walls are floodlights to illuminate the dark interior of the chasm.

Here, 65 to 100 feet below the surface of the moon, the visitors from the earth spend most of their time during their lunar visit.



PAINTING BY FRED FREEMAN



CHESLEY BONESTELL

Seen from abandoned cargo ship with "full earth" shining in sky, passenger ships take off for return trip from the moon to space station's orbit

of equipment and start hoisting men up to the catwalks of the two rocket ships. Then the cranes are folded against the framework, ready for flight.

Through the intercom, the commander of the fleet counts off the seconds to take-off. At X minus 4 seconds, a thunderous rumble sounds in the passenger spheres: the rocket motors have been started. The turbopumps are switched on, forcing hydrazine and nitric acid into the motors.

One by one, the ships slowly lift from the surface. An automatic pilot performs the complicated take-off maneuvering which will set us precisely on course for the space station circling the earth 239,000 miles away. We have timed our departure so that we shall arrive at the space station at the precise moment when its orbit is lined up with the direction of our travel.

Immediately after leaving the ground, the ship's four spiderlike corner legs are jettisoned to save weight; soon afterward, the central shock-absorbing leg is burned away by the fierce heat of the rocket motors around it.

By now, our earth-weight has returned, and we feel astonishingly heavy. As the ship picks up speed, we are made heavier and heavier by the force of acceleration, until at an altitude of 40 miles from the moon, about 2½ minutes after take-off, we weigh 3½ times normal earth-weight.

We have reached maximum powered speed at this point: 4,200 miles an hour, sufficient to counteract the moon's gravitational pull and its 2,280-mile-an-hour speed in its course around the earth. We can now cut our motors; momentum will carry us beyond the moon's gravity, and from that point on we'll simply fall toward our destination. As the flame of the rocket motors dies away, we become weightless once again.

From here on, the flight is routine. The navigators keep constant check on our flight path (we can change course by using our rockets), fixing the position of the ships in relation to star constellations and the steadily growing globe of the earth. Far behind us, and to the right, the moon becomes correspondingly smaller.

Once past the neutral point between the gravitational fields of the moon and the earth, we start our fall, picking up speed constantly. At a distance of 131,000 miles from the space station's orbit with 20 hours of travel to go, we hit a speed of 4,300 miles an hour. Eighteen hours later, a little less than 17,000 miles from the orbit, our speed reaches 10,500 miles an hour, and we start to think about slowing down. We cartwheel our ship (by using a flywheel which, turning in one direction, causes the ship to turn in the other), so the rocket motors point toward the space station. Now we watch our speed carefully. Ahead, the man-made satellite, looking like a bright star, is traveling around the earth at 15,840 miles an hour. When our speed reaches 22,200 miles an hour, we turn on the motors. Because they point in the direction of our movement, they act as brakes.

Gradually we slow down. As we get closer, we cut the motors to half power. The needle of the speed indicator backs across the dial. When it hits 15,840, our motors are off. We are now a satellite of the earth, traveling in the 1,075-mile-high orbit at just the right speed to counteract the earth's gravity. A few miles away is the space station, endlessly circling the earth at the same speed.

We are back at our starting point. Man's first exploration of the moon has ended. Space taxis speed toward us from the station. Other men pour out of the satellite's air lock to greet us.

Our next trip will be a short one: two hours to the earth, aboard one of the sleek rockets parked nearby. There, the members of our scientific panel await us—and, without question, a great crowd of earthlings, come to see the first men ever to set foot on the ancient, mysterious soil of the earth's closest neighbor in the heavens.