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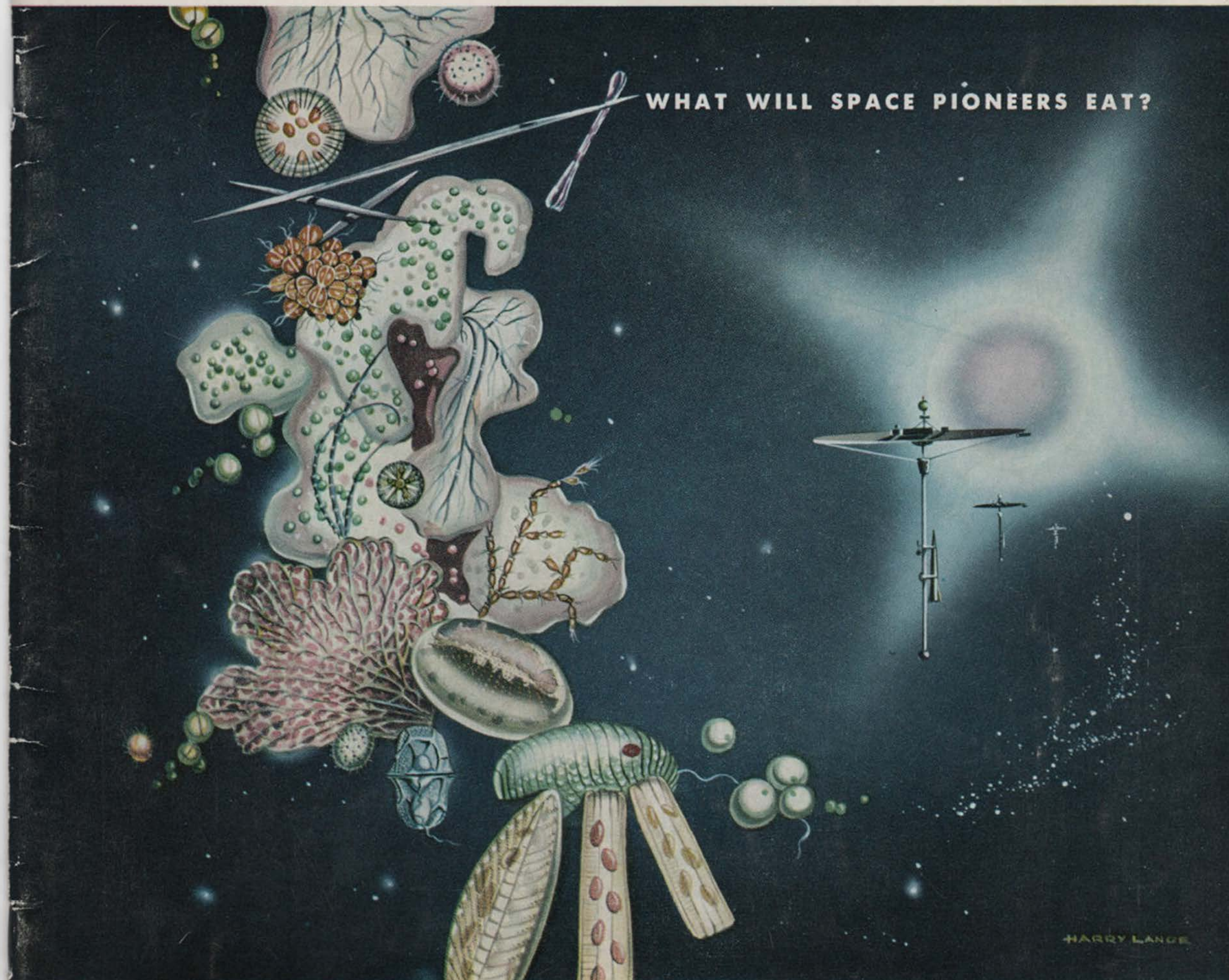

ALGAE AND LICHENS AGAINST A BACKGROUND OF ION POWERED SPACE VEHICLES

ROY MARQUARDT—RAMJET MAN

A SEARCH FOR THE SPACE MAN'S FOOD

PRIMITIVE FEAR—A FIRST APPROACH TO THE UNIVERSE

SPACE AND THE LAW

THE WEIGHTLESS MAN

VOL. 2 NO. 2 DECEMBER 1959

ARTICLES

DEPARTMENTS

SUBMISSION OF MATERIAL

Short articles of 500 to 3000 words are preferred. Send the original on white bond paper, typewritten, double spaced; plus two carbons. Key all illustrations with the text. Photographs should be 8 x 10 inches on glossy stock. A picture of the author and a short biographical note are required for publication. Security clearance for all material submitted is the responsibility of the author. Send material to SPACE Journal, P. O. Box 82, Huntsville, Alabama. All material accepted for publication becomes the exclusive property of SPACE Journal.

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Solid Fuels are simple—

ALWAYS A BRIDESMAID?

The question that we should be putting to ourselves these days is the implication of the latest Soviet success in the rocket field (in which they excell so well). If we learned nothing else from Lunik I, II and III, we have learned that the Washington government has not been exactly truthful with its pronouncements of "closing the missile gap". Many will now insist that they suspected that we were further behind than was officially admitted, but all of us were taken in to some extent. We shouldn't cry over spilt milk but if we can't learn from the school of hard knocks that the Luniks' have taken us through, then we had better get out of the business.

Lack of a centralized Authority with a planned, sensible program is our problem. The last football team that tried what the Washington government is trying in the Space race didn't fare any better than our space effort. The University of Miami (Fla.) tried to divide authority last season, different coaches were responsible for offense, defense, kicking, pass defense, etc. The result was that a team picked by many to go to the Orange Bowl on New Years day had one of their worst seasons on record. But, after all football is only a game and should be played as such, you can build character whether you win games or not. And, if winning games is important, you can always look to next year. But in the deadly serious business of ICBMs' with nuclear capabilities, the philosophy that you can run the scoreboard clock back and start again "all even" is a mistake that we cannot afford to make. In the nuclear game I doubt if our adversary will play according to our set of rules, even if he says he might.

We must consolidate our efforts and not have our potential divided between the NASA, ARPA, Air Force, Army, Navy and the Marines. We need a single agency with power of decision over all space activities. What would be wrong with giving NASA the teeth it needs and getting the show on the road. If we lose this game, we lose more than a New years bowl invitation.

NASA Report

A brief history—the NASA began operations on Oct. 1, 1958. It absorbed the personnel and facilities of the National Advisory Committee for Aeronautics, consisting of the nearly 8,000 scientists, engineers and technical and administrative personnel in the Washington headquarters and five field laboratories. The field installations are: (1) High Speed Flight Station, Edwards, California; (2) Langley Research Center, Langley Field, Virginia; (3) Pilotless Aircraft Research Station, Wallops Island, Virginia; (4) Ames Research Center, Moffett Field, California; (5) and the Lewis Research Center, Cleveland, Ohio.

The NASA also has a new space projects center under construction at Beltsville, Maryland, near Washington, D.C. It is scheduled to go into operation in early 1960.

In addition to the program that the NASA was to implement after completion of its initial organization, the NASA took over direction of five projects that were already under way. These were:

(1) A number of Advanced Research Projects Administration and Air Force engine development research programs, including their work on nuclear and fluorine rocket engines and study and development of the 1.5 million-pound thrust single chamber rocket engine.

(2) Five space probes which were under direction of ARPA.

(3) Project Vanguard, including the 160 scientists of the Naval Research Laboratory, Washington, D.C.

(4) Three satellite projects: 12 foot and 100 foot diameter inflatable spheres and cosmic ray experiment.

(5) Certain other projects under construction by ABMA.

In the week of Oct. 20th, 1959, the NASA obtained the transfer of the Army Ballistic Missile Agency to the NASA. This takes the Army out of the space field and gives the NASA the most famous research team in the free world. This added facility should give the NASA the finest research teams in the world.

Objectives of NASA—the three most ambitious projects that the NASA is now undertaking are:

1.5 million pound thrust booster. The engine is a booster rocket of 1 million pounds of nominal thrust, capable of being developed to a 1.5 million-pounds-thrust. It will use liquid oxygen and hydrocarbon propellents but could be adapted for other fuels. Special attention will be placed on methods of simplifying directional thrust-control and of pressurizing propellant tanks.

The program will provide a booster of great size for payloads and experiments weighing several tons. The booster will eventually be used to propel manned satellites and space craft. It will also be clustered to provide large payloads.

Manned Satellites—Project Mercury. Project Mercury has a three-fold objective:

(1) to study man's capabilities for space flight, (2) to place a manned satellite in orbit around the earth, and (3) to recover the man safely.

The capsule will be conical, about seven feet in diameter at the base and ten feet high. The pilot will lie in a couch-like frame, his back supported against the intense gravity stresses of take-off and re-entry. The base of the capsule will be mounted on an Atlas rocket. A suitable shield will protect him from the high friction-induced heat of atmospheric re-entry.

The satellite capsule will be launched into a circular orbit 100 to 150 miles above the surface of the Earth at a speed of 18,000 miles per hour. During the landing or recovery phase, retro-rockets attached to the capsule will fire, slowing the capsule enough to drop it out of orbit. The Earth's atmospheric blanket will brake the capsule even more. The last phase will take place when parachutes lower it to a landing. Escape mechanisms will be provided for emergency landings.

Careful selection and screening has reduced to seven the number of candidates for the capsule ride. Preliminary tests have revealed that the capsule into orbit and back will be a relatively safe journey.

Nuclear Energy Applications. The Atomic Energy Commission has longrange programs for developing nuclear reactors for application in spacecraft. The AEC also has under development small, light-weight nuclear power plants to provide electricity over long periods for satellite instrumentation and other space application—project SNAP (Systems for Nuclear Auxiliary Power). In addition to power from reactors, conversion of nuclear energy into electricity is being sought. The recently demonstrated SNAP III device which produces electricity by means of solid-state converters from the energy released by the radioactive decay of polonium or other radioisotopes. SNAP III has no moving parts, is very small and light, and has a long use-life.

The X-15 flight into space. The latest in a series of advanced research vehicles for high-speed, high-altitude experiments is the X-15 Rocket-Powered Research Aircraft. A joint undertaking of the Air Force, Navy, and NASA, the X-15 is expected to fly at speeds in excess of 3,600 miles per hour and to reach altitudes of 100 miles. It will be dropped from a B-52 bomber. The drop-launch will enable it to make a steep power climb toward the fringes of space, after which it will take a long glide back to earth.

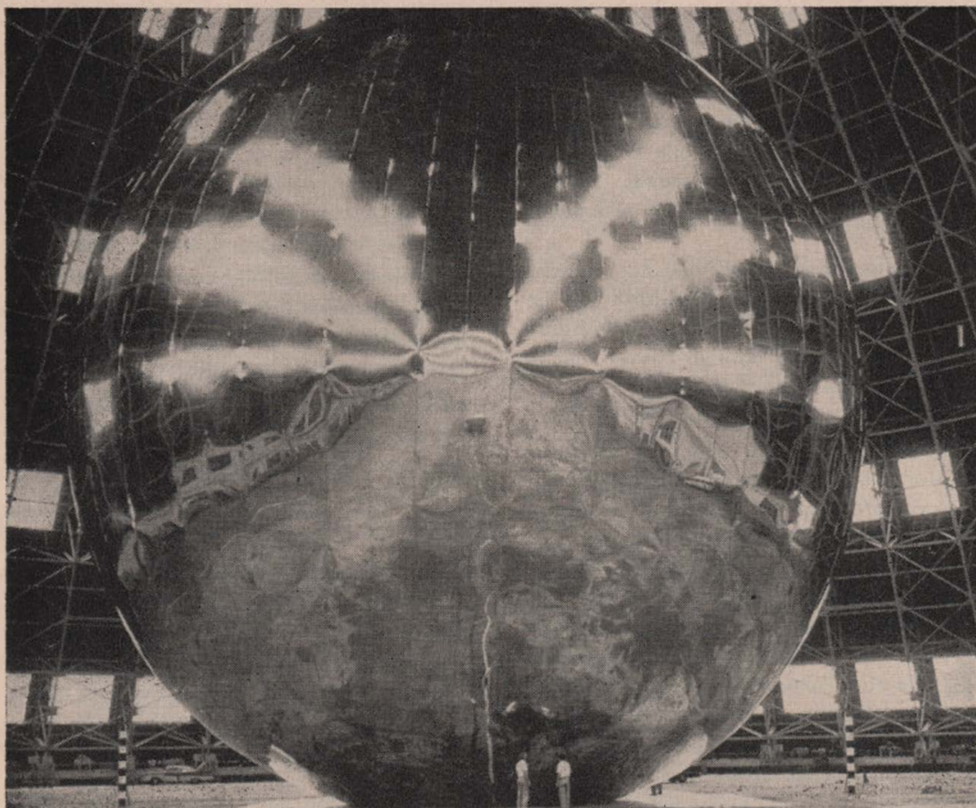
Through the flights of the X-15 the NASA will gather information about: (1) pilot reaction to flight during short periods of weightlessness; (2) severe aerodynamic heating caused by air friction at hypersonic speeds; (3) airplane stability and new types of aerodynamic control surfaces to keep the airplane flying on course at these great speeds; (4) rocket reaction control systems when the airplane is too high for aerodynamic forces to be sufficient; and (5) many of the exit, re-entry, and landing problems that spacecraft will encounter. Results of flights by the X-15 will have an important bearing on the manned space vehicle projects.

Space Sphere. At 5:45 p.m. EST, a 100 foot sphere was launched from the Wallops Island facility of the National Aeronautical and Space Administration. The launching, which took place on October 28, 1959 was to, in part, test the spheroid's ability to reflect the rays of the sun as it set.

As the ballon descended from clear skies into the Atlantic Ocean, it was reported from Maine to South Carolina. It was visible for about ten minutes before it was lost behind the horizon and fell about 500 miles due east of Wallops Island.

The launching was a test of the inflatable satellites which are to be used in communications experiments, as reflectors of radio and radar beams in space.

Professor Robert Brown, director of the New Haven, Conn., moon-watch station, followed the sphere and, before he learned what it was, said "it was the craziest thing in the world."



The sphere was launched by a two-stage rocket that was 32 ½ feet high and weighed 5 ½ tons at take-off. With an initial thrust of 130,000 pounds, this was the largest vehicle yet fired at Wallops Island.

Standing as high as a ten story building when inflated, the ballon was packed into a 26 ½ sphere for its ride aloft. The sphere was made of a mylar plastic coated with aluminum half of one thousandth of an inch thick. Upon ejection from its container, the sphere started inflating from the residual air inside it. Inflation was completed by the release of four pounds of water that was in plastic bags. The water vaporized inside the sphere and inflated it to 523,598 cubic feet.

It reached a peak altitude of 253 statue miles, and was tracked for ten minutes by radar at several stations. It was tracked optically by the Linclon laboratory station near Boston.

A telemetry radio transmitter was inside the sphere to record its performance, but the information it broadcast is not yet available.

Washington Report

STEEL STRIKE

Opinion on the hill is that the union stand has gone too far in regards to the current hike. Many representatives are concerned with rising un-employment because of lack of steel. Even pro-union members cannot defend strike in face of economy slow-down. Even more heat has been put on unions with statements by Glennan, NASA head, that missile production has been hurt by the strike and that work on the Vega missile has been delayed as much as three months. No action will take place in congress in the next session because of the election year, but look for a move to get under way in 61.

DEFENSE CUT-BACKS

Economy is the order of the day among all the servcies, with even the Air Force feeling the pinch. All will cut some manpower for next year and the Air Force will probably reduce the number of fighter squadrons it has active. There is speculation around Washington that all of the Air Force reduction in spending is not caused by lack of funds, but by a top flight decision to "leap-frog" into a more advanced type of missile. This would be comparable to the Russian move to missiles rather than try and develop a long range bomber. This decision gave them much of their head start in the missile race.

MISSILES

Minuteman and Atlas will probably get full go-ahead. Titan will probably be cut back. Most Titan will get is a small number of squadrons and some use in space probes and experiments. Air-launched ballistic missile is still very much in "air" and no firm decision has been made. This project will probably be shelved in favor of a longer range ramjet model.
Long range bombers are almost out.
Missiles to get the axe in the next twelve months are; Nike-Zeus, Bomarc, Titan, Nike-Hercules, Falcon, Mace, and the air-launched GAM-87A.

NUCLEAR PROPULSION PROGRAM

This project will be continued with General Electric and Marquardt donig most of the work.

MOVE OF ABMA TO NASA

This came as no shock to most on capital hill. Should have been done last October. Still not enough authority for NASA. Must have more and broader powers if the ever increasing gap between US and USSR is to be closed. Out look for next year. Gap will not close instead it will widen with several "new soviet first. Most logical next accomplishment? Man in orbit, perhaps by 1960. Next, will be successful moon landing with extensive data gathered. Perhaps a shot at Mars with photos similar to recent Moon shots.

roy marquardt, the ramjet man

by Lois Philmus

Since time began, man's imagination and ingenuity has perpetrated the great explorations of the world. And now it is man's faculties again that will permit the greatest exploration of all time—the plunge into space and the universe. Beginning a new series on the men with the brain power to provide the wherewithal to get there.

Ray Marquardt, founder of the Marquardt Aircraft Company.

"The ramjet is not through by a long way."

Does the ramjet engine have a place in the space age?

Yes, says Roy Marquardt—the man who rediscovered the ramjet and expanded its principles. "Satellite probes indicate that the atmposphere is higher than we previously thought. Thus, we can make better use of the oxygen through the wider use of ramjets."

The advantages? Weight and cost savings. The nuclear powered ramjet, now under research and feasibility studies as the Air Force sponsored Project Pluto, shows great promise for the future, Marquardt declared.

"The objective of the nuclear powered ramjet is to achieve better propellant consumption while still in the atmosphere by using the free oxygen rather than carrying it along in first and second stages as present systems do," Marquardt explained.

The theoretical savings in weight and cost through ramjet application could be music to the ears of the spacemen. As we advance farther and farther into the technology of travel into the universe, the entire program is threatened by estimates of the fantastic booster weights required to thrust larger and larger payloads farther and farther into space.

But what of the ramjet's one flaw—impotence in static thrust? Marquardt's company in Van Nuys is working on that solution also by combining the advantages of the ramjet with those of the rocket.

The marriage of a chemically powered rocket and the ramjet would provide the advantges of the rocket's static thrust to operate out of the atmosphere with the ramjet's superior performance at high Mach numbers while still in the atmosphere.

Possible?

Revealed Marquardt: "We have a working model under test."

Known as the perturbation cycle ramjet, a scale model has been successfully run combining ramjet-rocket power in which the rocket engine disturbs the incremental cycle of the ramjet.

Marquardt envisions that the perturbation cycle ramjet could be used in a concept which has ramjet engines as booster powerplants for space vehicles, instead of large rocket engine first stages.

His company holds Air Force contracts to explore the new space propulsion concept.

"The nuclear ramjet alone," Marquardt stated, "can carry a larger payload through the atmosphere at less weight and cost than present ballistic missile vehicles.

The very nature of the ramjet—a fantastically simple engine oft described as a "stovepipe"—is to carry large payloads for infinite distances at high speed through the atmosphere.

Just this summer Marquardt established a nuclear systems division to accelerate research *(Cont. on P. 39)*

a search for the space man's food

by Robert G. Tischer

THE FIRST MANNED FLIGHTS into Space will be of short duration, primarily designed to demonstrate successfully that a human operator can survive the extremes of acceleration, temperature, motion, and confinement, while maintaining his ability to make a sequence of correct decisions which will bring the ship safely back to Earth.

Painstakingly detailed study of this first vehicle and its one-man crew will reveal faults in construction of the ship and in the performance of the operator which can be used immediately to improve subsequent trips. Aside from the magnitude of forces involved, this excursion will resemble flights made routinely in high-performance aircraft now in use.

The crewman will be carefully selected, trained, and briefed. He will carry along a sufficient quantity of liquid oxygen to suffice for the projected length of the trip with a safety factor which will be adjusted to the best use of space and weight. A little water will be necessary to replace losses normal to the cabin environment of his Space ship.

Food during these first experimental flights will be carried along in small amounts or not at all. If food is included it will be used either for quick stimulation or for its psychological value, perhaps in combination with drugs, and certainly highly correlated with the personal desires of the crewman. This can be assumed from the fact that studies of nutritional patterns of human subjects under great stress more than suggests that the degree of emphasis on food decreases as the situation becomes more strenuous. Thus the immediate results of increasing the length of an excursion into Space will be to increase in proportion the demand for oxygen, water, and ultimately food.

While variety is not a factor in the provision of oxygen and water, it is an important one with food. The simplest diet may suffice for the shorter flights; but, in contrast, longer flights will quickly generate the desire for variety in the menu of the Space man.

For journeys of more than a few days, some method of preservation will be used to maintain the food supply in a safe and edible condition for the required length of time. With this in mind, all the common methods of preservation have been suggested and each has its merits. For example, precooked frozen foods would serve best on short and intermediate range flights where low temperatures could be maintained in insulated storage without mechanical refrigeration.

If the food supply were loaded into the Space vehicle at —200°F., the food itself would provide refrigeration sufficient to allow operation for a few days or even a few weeks —the exact time depending on the effective use of insulation. It is apparent that due payment must be made for the privilege of carrying foods at this low temperature in terms of a high energy requirement for thawing prior to use. This might still be an attractive method if the crewman agrees that the quality of his food is significantly better than that provided by other methods. Also, if cabin cooling is a problem, the food at very low temperatures would act as a heat sink for cabin temperature control.

Canned foods are recommended by their rugged stability but, in this case, not by their high water content nor the necessity for heavy metal containers.

Dehydrated foods have been suggested for use in Space vehicles with the idea that their low moisture content makes them an especially efficient cargo.

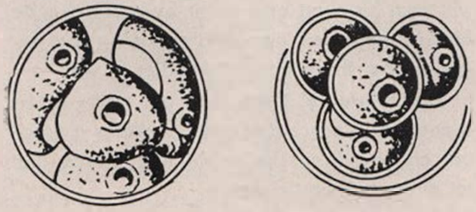
If water within the ship is not recycled, there appears to be no advantage of any kind in choosing dehydrated foods as any significant part of the Space crew menu. Since the water requirement of a man is practically the same whether he drinks his water or takes it in combination with one or another food, the absence of water in his dehydrated food would only dictate the presence of an equivalent amount in liquid form. Result: the net gain in weight conservation would be almost nothing.

The simplest recycling process is designed for the reuse of water through the activity of an ion-exchanger or by means of distillation processes. Operated efficiently this cycle would reduce water requirements to that amount needed by the Space man during the time necessary for recycling a roughly equal amount. With this change, the use of dehydrated foods becomes a much more prominent possibility. Apart from this advantage however, the burden of equipment for dehydration of dehydrated foods remains.

Closed-cycle feeding of crewmen in Space trips is usually constructed from two important components: a Space crewman and a microbiological regeneration system. The Space crewman is usually visualized as a less-than-average size man weighing between 100 and 140 pounds. A small man is chosen for the obvious reason that economy of both space and weight are, at least for the present, highly essential in the design and operation of Space craft. Only as soon as fuel-weight ratios are reduced will it be possible to contemplate large Space crews either individually or collectively.

The reasons for including a man at all in the Space craft have been critically reviewed by many authors. For our purposes, it is sufficient to conclude that he is most needed for control, through human judgement, of Space voyage situations which cannot be reliably predicted and therefore cannot be fully mechanized. Also, he weighs less than most computers of roughly equal ability.

But he must have daily about 1½ pounds of oxygen, five pounds of water, and a pound of food (dry weight). However, in the course of a small number of hours he returns to the system all of the water taken in—about five pounds—plus 11 ounces (330 grams) of metabolic water. And, too, all of the oxygen is returned as carbon dioxide along with four ounces (125 grams) of carbon dioxide pro-



One of 40,000 kinds of Algae.

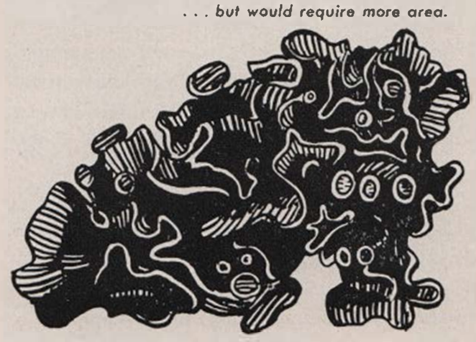
Lichens would require less water . . .

duced from the breakdown of foods. This leaves a remainder of approximately 1½ ounces (45 grams) of dry solids which are returned to the system each day.

While this gives the overall picture on a short term basis, it is clear that the growth of hair, nails, and skin would have to be taken into account at least in excursions of very long duration.

The microbiological regeneration system has already received many names and many identities, but all descriptions contain a plant which functions to produce oxygen from human wastes. The algae are usually preferred for this task since they are, by comparison with higher plants, of uncomplicated structure. Essentially, the alga functions entirely photosynthetically while higher plants have roots, stalks, blossoms, bark, and a complicated vascular system which may play no part at all in photosynthesis. This complication in structure seems, in some way, to be related to their possible use as human food. Observe, for instance, that we eat leaves, roots, stalks, blossoms, and even the bark of some of the higher plants while, with a few exceptions, the algae and other lower green plants are not as often used for food.

. . . but would require more area.



The advantage of photosynthetic efficiency of the algae is partly reversed by their requirements for large amounts of water to grow in and their lack of direct acceptability as human food. And it is these attributes which lead the designer of a closed-cycle feeding system to consider any one of a number of combinations of plants and animals to perform the combined functions of supplying oxygen, water, and food while existing entirely on a diet of human wastes.

The closed-cycle concept is almost invariably applied to long Space excursions which will take months or years. This is the direct result of a host of known and expected inefficiencies in the cycling operation. Ultimately, however, we should look forward to a closed-cycle system of high enough efficiency to compete with conventional feeding methods, even during short Space excursions.

What might be the requirements of such an idea system? How would it look and how would it function under the stresses of actual Space flight?

To house the system we should construct a cabin with a total volume of less than 50 cubic feet. The cabin will have a cylindrical shape in early models to maximize the efficient use of space in a vehicle of similar design.

The cabin will be completely sealed 48 hours prior to launching and rigorously checked and adjusted. Twelve hours later the Space man will be placed in a cabin simulator where the oxygen level built up to 50 percent to match that of the vehicle. Simultaneously the pressure will be reduced to half an atmosphere. Then, two hours before launching, the crewman and his immediate gear will be transferred through a pressure-lock to the cabin of the vehicle.

Lying prone on a contour bed he will have in his field of vision all of the instruments and controls with which he will work throughout the trip. He will also be in television contact with control operations informing him of the progress of preparations.

Finally the count down will start, the vehicle will rise slowly at first and then the traveler will zoom off into space.

After a brief blackout the crewman will regain consciousness and begin monitoring the vehicle's progress.

The oxygen he has consumed will be replaced by more supplied by an efficient light-weight bio-converter. This converter should weigh about 40 pounds and be built of light-weight plastic containing a radioactive isotope and a luminescent chemical which causes the inside of the converter tubes to glow brightly. Inside the tubes will be a dark-green mixture containing approximately 50 percent algal cells in water, under two atmospheres of pressure, being circulated very turbulently through the lighted tubes. At the intake end will be a regulating device which raises or lowers the oxygen output of the system to match the needs of the crewman while he is resting or working.

Solid and liquid human wastes will go directly to an incinerator-still combination which will first boil off the water through a condenser and an ion-exchange column to maintain a constant supply of pure water. The remaining dry substance will be automatically heated to higher temperatures and broken down into carbon dioxide, nitrogen, and water—all of which will be fed directly to the bio-converter. Under pressure, the carbon dioxide will dissolve in the converter fluid where it will be reconverted to oxygen.

The mineral salts remaining after the destructive distillation of the human wastes will be dissolved in water and metered into the bio-converter to complete the carbon dioxide-mineral salts diet of the oxygen exchange algae.

At another place in the converter a portion of the converter fluid will be drawn off, cooked thoroughly at a high temperature and pressure and partly dewatered. To this concentrate there will be automatically added a minute amount of flavoring material to make the algal soup palatable to the crewman.

Following a timed schedule, the crewman will take his food and water by a mouth-tube and in measured amounts, changing the flavor but not the texture of his diet at will.

The return to Earth will be followed by a debriefing procedure which includes a gradual change from the semi-liquid Space diet to a normal Earth diet.

(Continued on 45)

the weightless man

by Herbert D. Stallings

and Siegfried J. Gerathewohl

THE TWENTIETH CENTURY has seen many outstanding accomplishments. Among these are the development of the automobile, airplane, atomic fission, television, and great advances in medical science. We are now on the threshold of still greater challenge—the conquest of Space. While scientists knew of the future of Space travel and engineers dreamed of interplanetary rocket flight, it took an eye-opener from behind the Iron Curtain to convince the American public that the time is not too distant when manned vehicles will escape the captive pull of Earth's gravitation and speed into the infinity beyond our world.

When this occurs, the Space traveler will be subjected to the most fascinating condition associated with sustained rocket flight: The condition of zero-gravity, in which he will have no feeling of weight. As everyone knows, weight is the result of the tug of Earth's mass as it constantly pulls us toward its center. However, when the rocket ship cruises freely after burnout, it moves along a so-called Keplerian trajectory in a gravity-free condition. This trajectory is like the orbit of celestial objects such as the Moon or Earth. The speed of the body then creates a centrifugal force which exactly counteracts the pull of gravity. Such a trajectory need not be confined to the outer reaches of Space. Any craft with sufficient speed can fly through a Keplerian orbit a few miles above Earth where air resistance is low and excessive thrust can be used for overcoming drag. In jet aircraft, zero-gravity has been achieved for a maximum of about 43 seconds.

Obviously, before man is to be subjected to the strange and startling reality of zero-gravity for extended periods of time, research

Weightlessness—space bound (above) by Lt. Col. Robert B. Rigg

Weightlessness—earth bound (below) by Lt. Col. Robert B Rigg

must be conducted to investigate the effects of weightlessness on him in order that he be forewarned and prepared to meet this uncanny experience. At first glance, it might seem that weightlessness would be a very simple and pleasant sensation—rather like a relief from the everlasting burden of weight. But this is not necessarily true. On Earth we are never free from weight. Even the swimmer, lazily drifting on a pool of water, is subjected to the force of gravity and so are birds in flight. The dream condition of man floating and drifting weightlessly in Space is only a wish fulfillment which in itself recognizes the consciousness of weight.

Actual weightlessness can be experienced only when the force of gravity seems to be absent or is balanced by an opposing force. The first case occurs when a Space vehicle and its occupants escape beyond the pull of Earth's gravity and thus loses all weight. The second case occurs when the manned craft is orbiting around our planet: either in a rocket ship while cruising after burnout or in an artificial satellite while orbiting around Earth. In either case the result is a condition which can seriously affect the flier's well-being and his ability to respond and to perform his duties. This alone is reason enough for probing deeper into the effects of weightlessness upon man and his chances of survival during a trip into Outer Space.

Many suggestions have been made as to ways of producing zero-gravity and the weightless state associated with it. Since weightlessness can be produced in a free-fall situation, experiments after bail-outs or during jumps into a deep mine shaft have been proposed. Another method suggested was the use of the elevator, which would produce a state of subgravity for a period of time. The "Subgravity Tower" and the "Gravitron" devices for simulating the weightlessness condition by propelling a man up and down in a system of springs or in a U-shaped tube, were proposed and used for experiments in Italy. Moreover, weightlessness was partially simulated by the immersion of a body in water; and other experiments on orientation and equilibrium functions yielded interesting results. In such experiments the directions which we call "up" and "down" ceased to have conventional meaning.

Another, and perhaps the best, method devised to produce the weightless state is the use of jet aircraft. Since men most probably will never orbit around Earth in an aquarium but will penetrate the atmosphere in gigantic rockets, high-speed jet aircraft flying along a Keplerian trajectory seems to be the logical and most realistic approach to such an experiment. In addition, this type of high-speed aircraft provides a long enough period of zero-gravity to enable the experimenter to perform certain tasks and to secure all the measures necessary for his safety. The pilot, on the other hand, needs only to fly the airplane through the weightless maneuver, using experience and skill in order to guide the craft along an ideal parabolic arc.

It was not until the early part of 1955 that the United States Air Force's School of Aviation Medicine, located at Randolph Air Force Base, Texas, received a T33 jet plane to be used for zero-gravity research. In the beginning, practically no information was available on how a Keplerian trajectory could be flown other than the experience of several pilots who had known short periods of weightlessness during an outside loop or push-over maneuver. There was theory and some expert opinion; but we—that is, myself as pilot and Dr. Gerathewohl as chief investigator—began a series of exploratory flights to devise a flight profile that would give us the longest and most stable period of virtual weightlessness. Thus, trial and error within the theory of the ballistics of flying objects and artillery shells gave rise to the following flight pattern. At approximately 20,000 feet we nosed the T33 into a dive of approximately 45 degrees, throttle set at 96 percent engine power. Upon reaching an indicated airspeed of 350 knots, we began a pull-up which produced a radial acceleration of about 3Gs for 3 seconds, allowing the aircraft to be pulled into a steep climb of approximately 60 degrees from the horizontal. With wings level, sufficient forward-stick pressure produced a weightless state for approximately 28 seconds. We applied power on the upward portion of the arc and progressively reduced it at the peak of the curve and during the descending leg; this resulted in a constant velocity and zero-acceleration

(Continued on 41)

Major Stallines, Dr. Strughold, and Dr. Gerathewohl discussing a problem in front of the Air Force plane used in early weightless experiments.

throughout the arc. Roll and side sway were practically negligible throughout the maneuver provided aileron and rudder actions were absent and the air was calm. Only minute stick movements were necessary to keep the craft on its path.

The T33-parabolic curve was limited by several factors. Structurally, the aircraft was designed for subsonic flight. Because of its low Mach rating, entry speed and break-off points had to be determined so that maximum speed and climbing attitude could be attained without reaching the top of the curve below its stalling speed. The pullout also had to be completed before the plane oversped its Mach limit.

Fuel tank configuration produced another disconcerting condition. The T33 has a main fuel cell with the engine fuel pump located at the bottom of the tank. A portion of the top of the tank contains an air or expansion space connected to an overboard vent line. Zero-gravity allowed the fuel to float within this reservoir and permitted air and fuel to change places. Sustained zero-gravity replaced the fuel supply by air. The end product of this chain of events was a flameout.

The acquisition of an F94C Starfire jet aircraft by the School of Aviation Medicine early in 1956 enabled the experiments in weightlessness to continue with a more stable, safer, and longer period. By modifying the flight profile according to the higher thrust of the F94C, the period of virtual weightlessness was extended to 43 seconds. With this new aircraft we have been able to log an accumulative total of over 37 hours of weightlessness.

Many a reader may wonder about the benefit of this expensive and time-consuming type of research. Many may argue about the identity of the kind of weightlessness we produce, and the kind existing outside of the gravitational field of Earth. And some may still doubt that Space flight will be accomplished at all. To us, these objections are as familiar as the gravity-free state itself; and to us, the answers are obvious.

Today, only ignorance or prejudice can keep man from realizing that the Space Age has already begun. If people still consider the Sputniks, Explorers, Atlas, and Lunik nothing more than unimportant pieces of metal flying through space, they then do not understand fully the signs of our time. There *will be* manned satellites in the not-too-distant

Dr. Gerathewohl seated in cockpit of plane.

primitive fear: a first approach to the universe

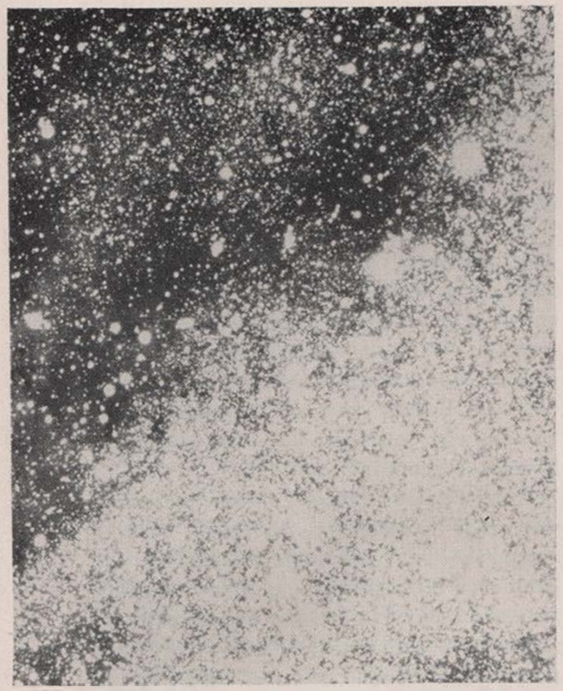
by John Hulley

No one planet is permanently safe. Survival depends upon mobility. If we remain isolated on this world, our species and all other life here will sooner or later be extinguished. If we discover, explore, develop and inhabit other planets, our chances of lasting survival multiply. If our explorations lead beyond this to other solar systems, our future approaches the eternal and our opportunity for expansion approaches the infinite.

TWO PRECEDING ARTICLES (SPACE Journal, summer and winter, 1958) linked the following points:

1. An apparently infinite quantity of planets affords opportunity for the profusion of life wherever radiation, planetary composition and other factors are favorable.
2. While evolution probably proceeds in all favorable opportunities, it may in many cases be interrupted. Changes in radiation, stellar explosions or collisions, cometary, planetary and galactic collisions occur only at long intervals; but the evolution of life is so slow that cosmic events may interrupt or retard it on many planets.
3. The direction of evolution is to fill every possible nook and cranny with increasingly adaptable and mobile organisms —populating the seas, then the land and air of the torrid zones and finally of the cooler zones.
4. To take advantage of all favorable planets, evolution may lead to species capable of carrying life from planet to planet. That may be the ecological purpose of man.

If these propositions are correct, it follows that we are integrally involved in the struggle of life to survive and expand amid the opportunities and dangers of this turbulent Universe. Appearing after millions of years of evolution, man incorporates the results of a long investment process. Upon us depends the survival of the life which has appeared on Earth. And through species such as ours, life may take early advantages of all favorable opportunities among the multitude of planets.



At the apex of the evolutionary pyramid, man need fear no rival terrestrial species. Even in the cave era, stone missiles, axes, spears, knives and fire made our ancestors masters of all other animals. But man is not master of the problems of survival in the Universe. Our complex nervous apparatus permits us to recognize and gradually to understand the elemental challenges of nature in the cosmos. With this recognition comes the need to respond.

The struggle to survive is essential in the life process. To survive, little fish must flee big ones, and rabbits must outrun foxes. Nearly all large species are subject to man. But man has the opportunities and dangers of the Universe to cope with.

Awe of the cosmic environment may be traced back to the earliest historic times and perhaps to the prehistoric period. It is expressed in most of the world's leading religions, and in some of the more profound philosophics. How our ancestors first became aware of the Universe around us, and how they reacted, is the subject of this article.

In the earliest times, our palaeolithic forebears seem to have given limited attention to the larger environment. The undifferentiated forces of nature provided general, unpredictable sources both of supply and of danger. The only thing men distinguished in detail was the animal prey on which they depended for survival. The hundreds of paintings and other artifacts which have been recovered from that period nearly all depict large mammals—mammoths, bison, giant deer, lions, rhinos and others. They showed no concern with background—no plants, rivers, mountains or skies.

Primary focus on prey may be a natural heritage from earlier forms of life; while the nervous structures of the more complex animals permit them to distinguish the environment in fine detail, these probably apply their powers almost exclusively to the identification of edible things and other immediate interests. The first men seem to have begun with a similarly narrow range of attention.

Even though they were not analyzed in detail, environmental forces certainly provided cause for concern. Storms, floods, hurricanes and tornadoes were presumably as frequent then as they are today. Solar eclipses, comets and other celestial events may have added to the uncertainties. Our forebears lacked precise means to cope with dangers only dimly discerned. However there are indications of a generalized response to these challenges.

Human reactions to vital concerns may be traced in the relics of religious activities. For ecological purposes, they contain the best evidence of the hopes and fears of early communities. Symbolic acts preceded writing by many millennia; indeed, men appear to have practiced rituals before the full development of speech.

The first two rituals centered on human life; they concerned birth and death. Perhaps a hundred millennia ago, Neanderthal men provided their dead with comfortable and warm surroundings, implements and joints of meat. While these men had a cranial capacity similar to our own, the attachments for their tongue muscles indicate that they spoke but haltingly; the rites were probably visual symbols, the meaning of which became more articulate in later times.

Twenty to fifty millennia ago, our Cro-Magnon ancestors began to make figurines of pregnant women; the few other sketches of human figures also emphasized generative powers.

Rites of birth and of the after-life have been practiced by a majority of societies. While their intensity and elaboration have varied considerably, they are the oldest and commonest in human experience on Earth. To interpret them is to try to understand the ideas our predecessors were acting out.

Anthropologists have theorized that birth and death are extremely disturbing to the continuum of community life and require ritual to ease the adjustment. The problem is then to understand why these processes should be so disturbing. The succession of individuals is nature's method of promoting the growth, evolution, variety and expansion of organic life. Other animal communities adapt to individual births and deaths in the most practical manner.

Extraordinary human reactions may reflect a profound concern with a problem which men could not exactly express and which they earnestly desired to solve. Welcoming birth and denying death may be symbolic ways of saying: At the mercy of forces not now fully understood, we intend to live forever. Births and deaths are the most readily identified processes in the rejuvenation of the community. Attention to them may reveal a mixture of anxiety for survival and hope for future fulfilment.

So far as the evidence goes, these symbols had only the vaguest context. Conceptions of the future were isolated thoughts, simple in form and general in location. As other rites were gradually added, they revealed a widening of human awareness, from the vague beginnings up to the time of a specific and primary concern with the heavens.

Men began to practice hunting rites toward the end of the palaeolithic era, perhaps twenty millennia ago. They drew, painted and carved images of their prey; in them they implanted spears and arrows. These rituals suggest that big game was becoming difficult to find and catch. They apparently expressed human desire to survive, and perplexity as to why the supply of large mammals was giving out.

In the next phase, roughly ten millennia ago, men worshipped images of small mammals, fish, large birds, and the like. These rites were associated with a conversion to the pursuit of small game, following the extinction of larger species. They suggest that the lesser prey were also becoming scarce in relation to growing human populations.

Scattered tribes have maintained a marginal existence, relying on totemistic rites of small game, until the present day. However, about eight millennia ago, leading groups began to shift to rituals concerning the fertility of land. Men developed farming, and for the first time entered into an operational relationship with some of the more elemental forces of the environment.

They devised intricate rituals concerned with food production. Fledgling farmers recognized that good crops resulted from the interaction of Earth, Sun, rain and rivers with the seed. But they did not understand why these forces were undependable. They compared the seeming vagaries of nature to the caprices of human beings and personalized them. Through imitative ceremonies and with offerings of choice food, drink, homes (shrines), songs and other attentions, they sought to influence the elements.

Another agricultural ritual concerned a deity who died and was resurrected annually. This rite may have reflected recognition that fertility is influenced by some other factor, which men could not easily identify: after repeated plantingsof identical seed, the depleted topsoil no longer produced the same rich crops. Rites to cope with such fertility problems are still practiced in many parts of the world today.

At about the same time, our ancestors began to worship male cattle. In developing the husbandry of animals, men probably learned that some species will mate in captivity, while other will not; some live, while others sicken and die. Human dependence on the increase of livestock may account far the worship of the most reliable breeders, especially the bull and the ram.

Farming communities could support priest specialists solely concerned with efforts to bring about favorable conditions. Individual farmers too had idle time to ponder. Thus men began to segregate the conglomerate

(Continued on 46)

space and the law

by Menachem Sheffy

While technology is striving to make the conquest of Space a splendid reality, our sense of normative order has promoted extensive discussions as to the legal implications of our leap into the cosmos. So lively have the deliberations of lawyers become, they induce an eminent scholar, Myres S. McDougal, to observe wryly: "The conquest of Space has barely begun. Yet the law of Space, instead of lagging behind as some lawyers fear, is threatening to outfly the attraction of the Earth's gravity."

To be sure, "the law of Space" has yet to come. At present it is largely confined to theory and speculation motivated by a sense of urgency rarely demonstrated by international jurists. Why our venture into Space should fill distinguished lawyers with a feeling that the legal determination of the status of Space is so pressing a problem is indeed a question worth examining.

Since the launching of Sputnik I, the power struggle raging on the surface of our planet is threatening to expand into our cosmic environment on the heels of scientific progress. As out of date as it may sound, we are presented with the ominous prospect of Space becoming an arena for political conflicts filled with dangers of unprecedented dimensions. Comparably with the discovery of the lethal capabilities of nuclear energy, the conquest of Space may present mankind with the fateful choice between tremendous progress on one hand, and its obliteration from the face of Earth on the other. The romanticists among us might shudder at the idea of the Moon becoming an object of controversy between nations, but such a prospect is indeed conceivable, with possible consequences far removed from the realm of abstract discussion.

To forestall these dangers, voices have been raised demanding an early international agreement on the status of Space, barring its exploitation for warlike purposes. Whatever rights states may claim in Space, it is imperative that its use be restricted to peaceful aims. Surely we cannot afford to be merely legalistic in so vital a matter; whatever sovereignty is asserted in Space, it must be subjected to this qualification.

In spite of international agreement, does the law of nations in its present form provide us with answers relevant to Space? Some lawyers advance the proposition that the first Space law doctrine has already been laid down by the practice of states. They argue that the fact that no single state has protested against the orbiting of satellites over its territory constitutes tacit agreement to the principle that Space may not be made an object of national acquisition. The validity of such a deduction is indeed questionable. We cannot ignore the fact that the Sputniks and Explorers launched thus far are national enterprises undertaken under the IGY program, and states may interpret their tacit agreement as of a nature limited to activities under this program. Furthermore, though the origin of doctrines of international law is possible in this manner, it is far more profitable, in an area as important as Space, to have a positive and express agreement on the subject.

The lack of explicit law regarding Space suggests a turn to analogies. Two areas of international law readily lend themselves to analogy: namely, the law of the air and the law of the sea. We should, however, bear in mind that analogies serve only as indications of possible legal solutions without, in themselves, determining the law.

The latest restatement of the status of the air is embodied in the Convention on International Civil Aviation of 1944 (the Chicago Convention). Article 1 of this Convention reads: ". . . every state has complete and exclusive sovereignty over the airspace above its territory." We have no definition of the term "airspace" or any indication as to where it ends and Space "proper" begins. By no measure of interpretation may we say that this article applies to Space as well. That the framers of the convention did not have Space in mind when using the term "airspace" is a fact attested to by the eminent historian of air law, John C. Cooper, who served as chairman of the committee that drafted this article. The consensus of opinion is that "airspace" is the area in which aircraft fly. We can hardly consider movement in Space as flying, nor is a spacecraft the equivalent of an aircraft. While it is commonly accepted that the Chicago convention does not apply to Space, it remains to be seen whether we can draw an analogy from the status of "airspace" for the purpose of determining the status of Space. Should Space above states be considered part and parcel of the national domain, then sovereignty would extend upwards indefinitely. The difficulties inherent in such a concept of the national domain are practically insurmountable. For one thing, the rotation of our planet places, at various times, different portions of Space over a given territory. For another, it would be impossible to determine borders in Space and decide when a violation of "national Space" occurs.

The status of the high seas offers a more workable analogy. The high seas, for example, are open to all nations with no single state legally entitled to proprietary rights beyond its territorial waters. This concept is steadily gaining ground in the deliberations concerning the status of Space. The secretary general of the United Nations voiced a popular opinion when advocating last May that outer Space be accorded the same status as that of the high seas and that nations renounce any claims to it. The National Council of the Federation of American Scientists expressed similar sentiments, saying that "it would be tragic if the challenging task of Space exploration were carried on in the competitive nationalistic pattern under which it has begun."

Those objecting to the concept of Space devoid of national control argue that security considerations necessitate that states have exclusive jurisdiction in Space above their territory. It is pointed out that Space may be used for military aims even during peace time for such purposes as reconnaissance and the monitoring of radio communications. We have noted the physical difficulties in exercising such jurisdiction. Furthermore, whether alleged security considerations outweigh the advantages to be derived from a free and internationally controlled Space is highly questionable. Should arguments in the name of national security be motive for the determination of the legal status of Space, why should we not apply it first to the high seas? It is submitted that the high seas infested with missile-firing vessels pose as real a threat to the territories of nations as Space. Admittedly, the status of the high seas was established long before the introduction of modern missiles and it would be difficult to reverse time-tested, customary law. All in all, the argument that free Space may become a menace to states only underscores the demand that its free status should exclude its use for military ends.

The destructive capability of today's weapons makes it imperative that Space be an area of peaceful activities. Freedom of Space must also be freedom from fear of an attack from Space or its abuse. Accordingly, any international agreement on the status of Space should include a pledge by all nations to this effect.

Professor Cooper, in an attempt to compromise the two extreme views of open and restricted Space, suggests the adoption of concepts of territorial sea and contiguous zones in determining the status of Space. These suggestions amount to a vertical division of Space whereby, above a certain height, it would be open to the vehicles of all nations. An intermediate zone would assume a status similar to that of the territorial waters with the right of "innocent passage" used freely.

(Continued on 47)

atlas missile

The Weapon System—The Atlas (SM-65) is America's first intercontinental ballistic missile. With associated ground equipment it comprises the Air Force weapon system WS 107A-1. The missile has been developed in a flight-test program that began in mid-1957. It is in production at San Diego by Convair (Astronautics) Division, General Dynamics Corporation.

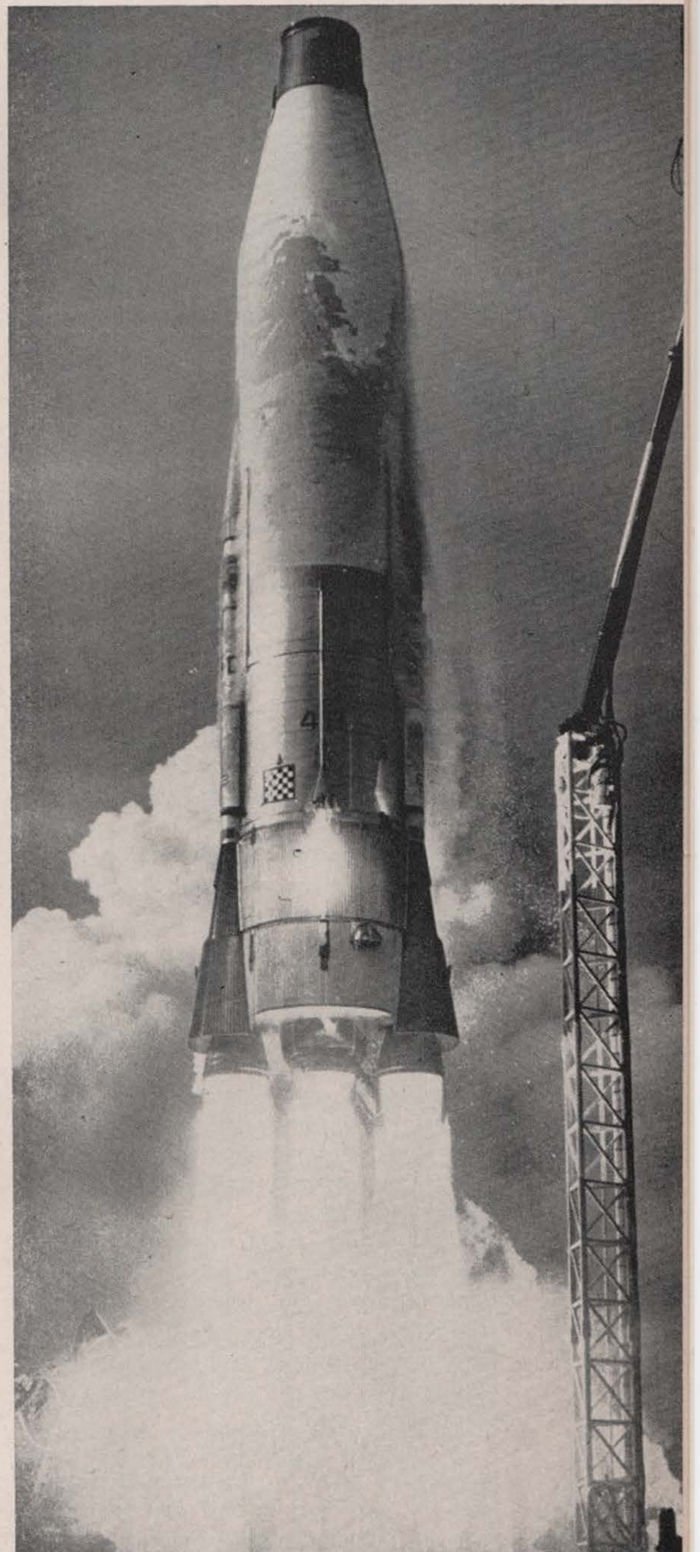
Atlas was the first missile to lift itself into orbit without extra rocket stages, and is being used in a number of pioneer space projects.

The Missile—The Atlas is designed to deliver a thermonuclear warhead more than 6,000 statute miles (5,500 nautical miles). It is powered by liquid propellant rockets—two large boosters, one large sustainer and a pair of small "vernier" rockets. All burn liquid oxygen and RP-1, a kerosene-like hydrocarbon. Takeoff thrust is approximately 360,000 pounds. Takeoff weight is about 260,000 pounds. The missile is 75 feet long and 10 feet in diameter. Some flight versions with a pointed nose are 82 feet long.

The unique Atlas propellant tank is made of tough, lightweight stainless steel, thinner than a dime. The tank, measuring about 60 feet in length, has no internal framework. It is kept under pressure to retain its shape. This results in a tremendous weight saving. A special cold-rolled austenitic steel (AISI grade 301) was perfected for the Atlas, and Convair worked with the welding industry to develop new welding techniques and equipment for fabrication. Skin gages vary throughout the structure, being tailored to meet local stresses. The heaviest gage is less than 40-thousandths of an inch. The thinnest wall section meets a specification for minimum tensile strength of 200,000 pounds per square inch.

The missile contains more than 40,000 parts (not counting subsystems supplied by associate contractors—engines, nose cone, guidance, etc.)

In a unique staging version originated by Convair, all five rockets are ignited prior to launching. After a few minutes of flight, during which the missile is lifted well into its trajectory, the booster engines and associated



ATLAS STARTS LONG TRIP—Pouring a torrent of fire from its three rocket engines, an Atlas intercontinental ballistic missile rises from its launch pad at the Air Force Missile Test Center at Cape Canaveral, Fla. Photo shows the start of the successful flight of Aug. 2.

equipment are jettisoned to lighten the load. The sustainer engine continues to accelerate the missile until it has attained a velocity on the order of 16,000 statute miles per hour. Then the sustainer is shut off, and the small vernier rockets are used (if needed) to "trim" velocity to the exact value required.

After vernier shutdown, when the missile is following a purely ballistic (unguided) course, the nose cone is separated from the rocket structure by firing small retarding or "retro" rockets. Nose cone and tankage travel in a high arc through outer space until the atmosphere is re-entered. Then the tank structure is destroyed by frictional heating.

(Conventional long-range missiles consist of two or more rockets, one mounted on another. The bottom or booster rocket furnishes all power until it burns out. Then it is dropped and the next stage is ignited. The Atlas system, with its unique "one and one-half" staging, differs from the other modern missiles in having two sets of engines but only one fuel tank structure. This permits igniting all engines, including the upper-stage (sustainer) engine, on the ground. There is no risk that the missile will abort through failure to achieve ignition of a second stage many miles in the air. This achieves a remarkable improvement in missile reliability. The "one and one-half" principle was first advocated by Convair in a report to the Air Force in May 1949.)

During powered flight the course and speed of Atlas are governed by the guidance system. The missile employs radio-inertial guidance (requiring a station on the ground) through the period of early operational use, then changes to all-inertial (self-contained) guidance. Using self-contained guidance, the missiles can be fired in a single salvo, instead of being launched in series.

Flight Testing—Flight missiles are shipped from the factory to the Atlantic Missile Range, Cape Canaveral, Fla., where Convair maintains a field staff of more than 1,000 persons. Here Convair, as agent of the Air Force, puts each missile through ground testing, final checkout and test flight.

During a flight, data from more than 150 instrumented points in the missile is telemetered (radioed) back to AMR over nearly 50 channels. This information—recorded on some 10 miles of magnetic tape—includes temperatures, vibrations, accelerations, liquid flow rates, etc. From this information, engineers can reconstruct an Atlas flight in detail.

Flights to Date—Atlas flight testing started at Cape Canaveral in June 1957, using Series A missiles fitted with booster engines only and having dummy nose cones. The range for these flights was limited to approximately 600 miles. In eight such flights, the missile never failed to launch smoothly and retain complete stability during vertical rise.

On the first two flights (June 11 and Sept. 25, 1957) the missiles malfunctioned after starting pitchover into trajectory and were destroyed by the range safety officer. Successful flights followed Dec. 17 and Jan. 10.

Testing of the complete missile, having both sustainer engine and separable nose cone, started in the summer of 1958. A control system "random failure"* caused the first three-engine Series 8 Atlas to break up in flight July 19. The second was launched successfully on Aug. 2, attaining a range of more than 2,500 miles. Successful longer-range flights followed Aug. 28 and Sept. 14, and a full-range flight of well over 6,000 statute miles was made Nov. 28. Missile 10-8 was fired into orbit Dec. 18. The first Series C Atlas was launched Dec. 23. Series D testing started in the spring of 1959, and the first fully successful flight was made June 20.

Ground Testing—Atlas missiles assigned to ground testing are sent to two California facilities, Sycamore Canyon, near San Diego, and the Missile Static Test Site (formerly Edwards Rocket Base), to be expended in a rigorous and exhaustive program of captive testing.

History—The Air Force in 1946 awarded Convair the first research and development contract in a program to develop a missile capable of carrying a warhead 5,000 miles. (At that time the only long-range rocket was the 200-mile German V-2.)

Convair designers under Karel J. Bossart (later technical director of Astronautics)* conceived and developed the MX-774 research

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* A random failure is comparable to having a flat tire on a modern automobile. One expects to make hundreds of trips without tire trouble—but there is always the possibility of having a flat on the next trip out.

* Bossart was awarded the Exceptional Civilian Service Award by Air Force Secy. James H. Douglas in 1958.

rocket. This introduced three innovations which have since become part of the universal art of rocketry:

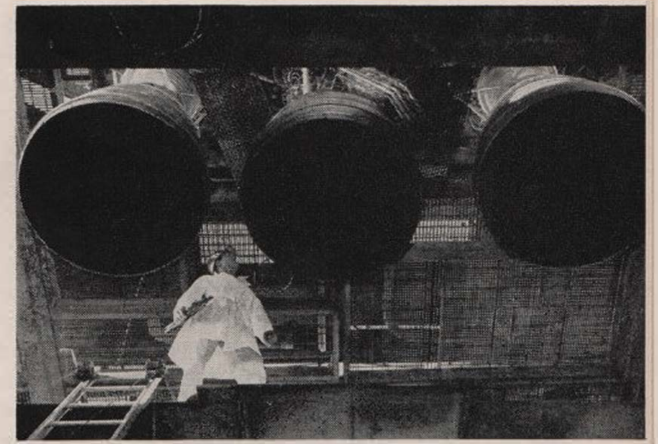
1. First swiveling of engines for directional control. (The Germans controlled the V-2 with rudderlike graphite vanes placed in the jet stream.)
2. First "integral" tanks—the skin of the missile serving also as the wall of the propellant tanks, thus achieving a tremendous weight saving. (The Germans used separate internal tanks.)
3. First separable nose cone. (The Germans re-entered the complete rocket structure.)**

Defense Department economy cutbacks in 1947 led to shelving of ICBM development, but unexpended and supplementary MX-774 funds enabled Convair to complete 3 of the 10 MX-774's under construction, conduct the first captive firing in November 1947, and launch the completed rockets at White Sands Proving Ground in 1948. From then until early 1951, the company continued limited ICBM studies with its own funds.

The Air Force renewed ICBM work on a conservative scale in January 1951, giving Convair a study and development contract.

The program was named "Atlas" that fall. By 1953 Convair had developed essentially the present Atlas design—pressurized stainless steel tanks, one and one-half staging, vernier trim rockets, gimbaling engines, radio-inertial guidance, etc.—and construction of the first test tank started that winter.

In this original version, the Atlas was to be equipped with five main engines developing takeoff thrust of more than 600,000 pounds. North American Aviation, which had worked on Atlas propulsion as a subcontractor, was made a full associate contractor of the Air Force in 1954.



This is the Atlas intercontinental ballistic missile propulsion system, generating 360,000 pounds of thrust. In long-range flight tests, this engine has hurled the Atlas over 6325 miles from the launching pad at Cope Canaveral, Florida. Made by Rocketdyne, a division of North American Aviation, Inc., the primary units are composed of a twin-chambered booster at left and right, a sustainer in the center, shown here being inspected by Al Smith, Rocketdyne Field Service representative. The propulsion system also includes two small vernier, or stabilizing engines, mounted on the missile frame to prevent roll.

During 1954, successful testing of small nuclear devices (Operation Castle) led the Air Force to accelerate the ICBM program. The present Air Force Ballistic Missile Division was created to manage it. Atlas was redesigned to the present three-engine configuration by December, and Convair received a production contract in January 1955.

Atlas fabrication began in San Diego in 1955. First engine tests were conducted at Edwards in June 1956; the first completed missiles were delivered to Sycamore and Cape Canaveral that fall.

Associtaes—As systems integrator for Project Atlas, Convair builds the airframe, the autopilot system and various components; assembles and checks out the missiles; conducts both captive and flight tests for the Air Force; activates new Atlas bases under direction of the Air Force Ballistic Missile Division, and trains Air Force personnel.

Associate contractors, in addition to Rocketdyne, include General Electric Company and the Burroughs Corporation, radio-inertial guidance (to be followed by American Bosch Arma Corporation, all-inertial guidance); and General Electric Company and Avco, nose cones.

Research and development phases of Proj-

** Over the years there have been other major Convair innovations. Two that should be noted:

Tracking—A unique electronic tracking/guidance system was conceived by Convair in 1946, in connection with MX-774; when missile work stopped, the Air Force continued support of this development, called the Azusa system. It became the range tracking system at Cope Canaveral, now used on all missiles launched there.

Verniers—When powered flight ends, ballistic missiles must have the exact velocity required for a given trajectory. Convair evolved the techniques now in general use: After shutdown of main engines, small accessory rockets ("verniers") are employed for precise adjustment of velocity.

ect Atlas have been directed since mid-1954 by the Ballistic Missile Division, ARDC, Inglewood, Calif., now commanded by Maj. Gen. Osmond J. Ritland. At Cape Canaveral, Convair launching complexes and assembly/checkout buildings are part of the Atlantic Missile Range, ARDC, commanded by Maj. Gen. Donald N. Yates, with headquarters at nearby Patrick Air Force Base.

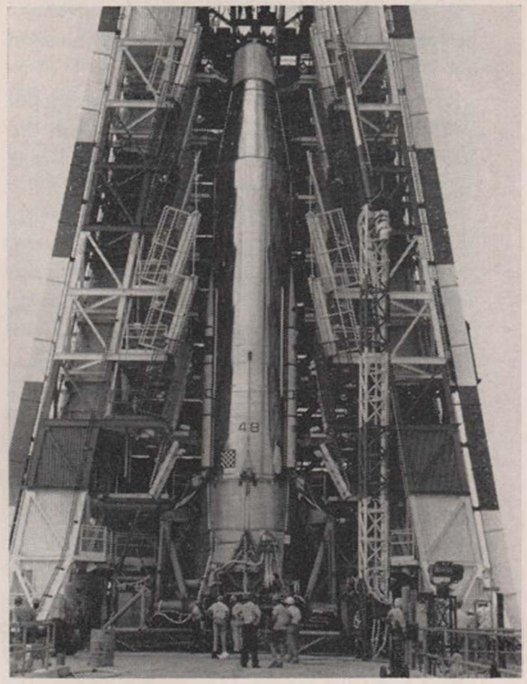
Looking Ahead—The Atlas is achieving operational capability in 1959. The operational force will be part of the Strategic Air Command, commanded by Gen. Thomas S. Power. SAC's 1st Ballistic Missile Division, commanded by Maj. Gen. David Wade, has headquarters at Vandenberg Air Force Base, Lompoc, Calif., a combined operational and training base. The first SAC-launched Atlas was fired from Vandenberg by the 576th Strategic Missile Squadron on Sept. 9, 1959.

Work is well advanced on two of the three complexes planned for Francis E. Warren Air Force Base, Cheyenne, Wyo. Other Atlas bases will be situated at Offutt AFB, Omaha, Neb.; Fairchild AFB, Spokane, Wash.; Forbes AFB, Topeka, Kan.; Schilling AFB, Salina, Kan., and Lincoln AFB, Lincoln, Neb. Convair is assisting the Air Force in the installation of training facilities at Sheppard AFB, Texas, and Chanute AFB, Ill. Atlas squadrons at Vandenberg, Warren and Fairchild are assigned to the 15th Air Force (March AFB, Calif.); those in Kansas and Nebraska, to the 2nd Air Force (Barksdale AFB, La.). Each squadron will have 10 missiles.

Convair is responsible to AFBMD for establishing technical criteria for Atlas complexes, for integrating the installation of ground support equipment, for checking out complexes, and for activating them and turning them over to the Air Force in operational condition. The company began training Air Force operational instructors at San Diego in June 1958.

As the first extensively tested ICBM, and the first to launch itself into orbit, Atlas has become the sturdy wheelhorse of the Early Space Age. Missions announced to date, and now under way, include:

1. *To boost the first U.S. manned capsule into orbit.* (This is Project Mercury.)
2. *To boost an instrumented probe into space.* (This is Atlas-Able 4, one of the Air Force "Able" shots, combining Atlas with three upper stages.)
3. *To boost the first heavy satellites into polar orbit.* (Projects Midas and Samos.)
4. *To boost the first "medium energy" vehicles into high orbit.* (This is Vega, combining the ICBM with a Convair-built second stage, and a storable propellant third stage. Early missions are expected to include scientific earth satellites, moon probes and planetary probes; later missions may include two-man space capsules, television surveys of the moon, and lunar satellites.)
5. *To boost the first "high energy" vehicles into distant orbits.* (This is Atlas-Centaur, combining the ICBM with Convair-built second stage, the latter having the first liquid hydrogen rockets. A storable propellant third stage, as in Vega, can be added when necessary. Initial capabilities will include soft-landing a half-ton payload on the moon.)



ATLAS IN TOWER—The huge Atlas intercontinental ballistic missile is shown here in a test stand at the Air Force Missile Test Center in Florida. The missile stands as tall as a seven-story building. This view shows an Atlas at AFMTC before the successful launching of Aug. 2. Work platforms have been folded up to permit withdrawal of the mobile steel gantry tower.

ATLAS ON LAUNCH PAD—Towering some 75 feet above the elevated launch platform, an Atlas intercontinental ballistic missile is readied for test flight at Cape Canaveral, Fla. The massive steel service tower has been withdrawn from the pad. The slender gooseneck boom carrying power and instrument lines to the nose cone swings away shortly before launch.

Since 1952—Convair began space studies in 1952. The first report on satellite capabilities of the Atlas was published as a classified document in May 1953. That fall Convair proposed use of the Atlas to place a TV-equipped military reconnaissance satelite in polar orbit. Space studies continued under the leadership of Krafft A. Ehricke, who joined Convair in 1954. In 1957, after Russia's launching of the first satellite stirred strong U.S. interest in space, Convair was able to present a comprehensive satellite and space development program to government agencies. (One recommendation was for development of an upper-stage rocket powered with liquid hydrogen. Such a program is now under way in Project Centaur.)

Talking Satellite—In a project sponsored by the Advanced Research Projects Agency, Atlas Missile 10-B was launched into orbit from Cape Canaveral at 6:02 p.m. Dec. 18, 1958. Fewer than 100 persons knew of the project until President Eisenhower announced two hours later that Atlas was circling the earth.

The 122-pound payload, installed by the Army Signal Corps, consisted largely of duplicate communications relay equipment, designed to tape-record radioed voice or code messages and rebroadcast them upon command from the ground. The first words broadcast from space were:

"This is the President of the United States speaking. Through the marvels of scientific advance, my voice is coming to you from a satellite circling in outer space. My message is a simple one. Through this unique means I convey to you and to all mankind America's wish for peace on earth and good will toward men everywhere."

Successful experiments continued for the life of the batteries, through December. The satellite is believed to have re-enterd the atmosphere and burned on Jan. 21.

Key data (all miles statute) included: Takeoff weight approximately 245,000 lb.; booster package jettisoned normally; sustainer shutdown after some 4½ min. of flight, when velocity was 25,394 ft. per sec. (17,314 mph) relative to earth's surface. Initial estimates of satellite weight (8,700 to 8,800 lb.) were refined to "not more than 8,661 lb." after detailed analysis. (The weight of residual propellants cannot be determined precisely.) Orbital data: initial perigee 110.6 mi., apogee 911 mi., period 101 min., inclination 32.3°.

Project Mercury—Initiated by the National Aeronautics and Space Administration in October 1958, this is a program to put the first U.S. manned capsule in orbit—"an arm-stretching, mind-stretching undertaking that thrills everyone of us," Administrator T. Keith Glennan has said.

The capsule, to be boosted into orbit by the Series D Atlas, is under development by McDonnell Aircraft Corp. Roughly conical in shape, it is approximately 7 feet across the base and 10 feet high. A boom carrying emergency escape rockets is fitted atop the capsule during launching but is jettisoned once the capsule is safely in orbit. A special couch-like seat will support the pilot during takeoff acceleration and again at re-entry (when the capsule will come into the atmosphere base-first).

Launched from the Atlantic Missile Range, the capsule will circle the earth at an altitude of 100 to 150 miles, for up to 24 hours, before descent is initiated by firing retarding rockets. After the vehicle has been slowed by aerodynamic drag, parachutes will lower it to the surface, and a fleet of recovery ships will rendezvous to pick it out of the water.

An extensive test program, including experimental launchings with smaller rockets, is planned during 1959. The first "Big Joe" flight was made with an Atlas Sept. 9. Meantime, a team of seven Air Force, Navy and Marine volunteers is receiving "the most extensive course of training ever offered to a party of prospective explorers." One flier will be picked to make the trip just before the first manned launch.

The capsule flights will lead eventually to establishment of a permanent manned satellite, NASA had said.

Project Vega—A multi-stage rocket, Vega will be the first U.S. space vehicle in the "medium energy" class—capable of putting a 5,800-lb. weather satellite in orbit 300 miles above the earth. Vega can be used as a two- or three-stage vehicle as required. This program is directed by NASA.

The first two stages will consist of the Series D Atlas topped by another Convair-built vehicle. Jet Propulsion Laboratory, operated under contract to NASA by California Institute of Technology, will supply a third stage and will have technical direction of the Vega program.

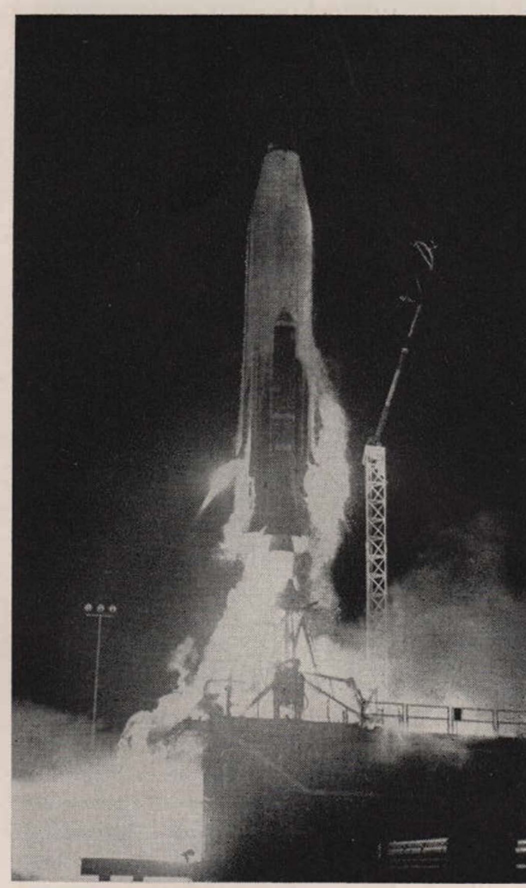
The second stage will be powered by a modified version of the General Electric Company's Vanguard power plant (liquid oxygen and kerosene), developing a thrust of 35,000 pounds. Modifications made by GE will include development of a system permitting the engine to be stopped and restarted in space, so that a precise orbit can be established at high altitudes.

The third stage will be powered by a 6,000-pound-thrust storable-propellant engine, now under development by JPL.

In the three-stage configuration, NASA Administrator Glennan has said, Vega will have the potential to put a 740-pound experimental communication relay into the 22,000-mile or "24-hour" orbit.

At this altitude, the speed of a satellite fired eastward along the equator just matches the rotation of the earth; the orbiting body appears to remain stationary in the sky.

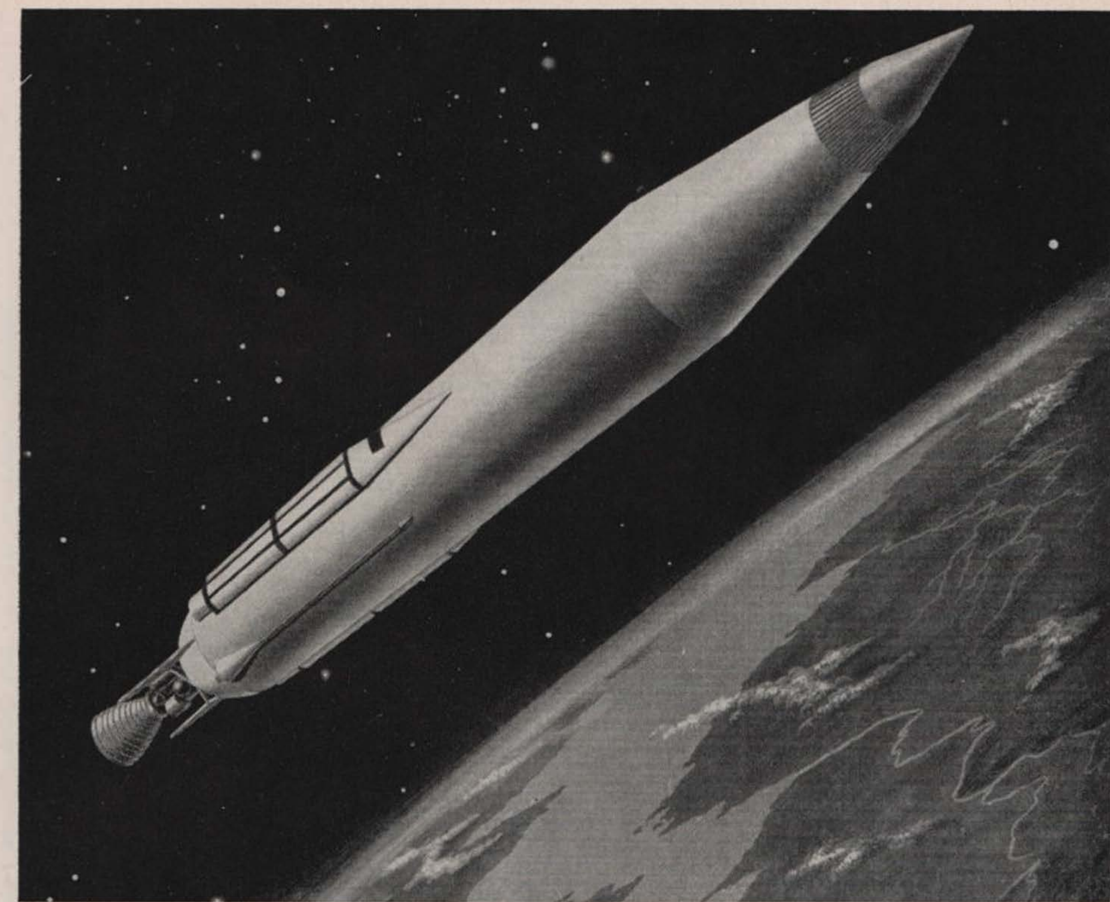
Using such satellites as radio or TV relay points, the U.S. could conduct worldwide commercial and military communication, or beam television programs abroad. (It has been estimated that U.S. overseas messages will climb from the 1.5 million of 1950 to 3 million by 1960; and if facilities are available, to some 20 million by 1970.)



ORBITAL ATLAS BEGINS HISTORICAL FLIGHT—An Air Force Atlas intercontinental ballistic missile rises from a launching pad at the Cape Canaveral, Fla., Atlantic Missile Range, to begin a journey that covered millions of miles through space. This was Atlas 10B, placed into orbit Dec. 18, 1958, the only rocket in the Free World capable of propelling and guiding itself into a satellite path around the earth. The entire 82-foot missile, minus its jettisoned booster engine package, remained in orbit 33½ days, to become the largest satellite launched by any western nation. Lifted by approximately 360,000 pounds of thrust from its five rocket engines, the Atlas had achieved its earth-circling ellipse approximately 4½ minutes after this photo was taken. It made 500 revolutions before re-entering the atmosphere and burning up on Jan. 21, 1959.

NASA has contracted with Convair for eight Vega flight vehicles and one engineering evaluation vehicle, at a cost of $33,500,000 (not including the Atlas boosters or the GE engines. The boosters will be procured out of Air Force-allotted missiles.)

Project Centaur—The first U.S. space vehicle in the "high energy" class, Centaur will be capable initially of putting heavy (4 ½-ton)



ARTIST'S CONCEPTION OF ATLAS IN ORBIT—The Atlas intercontinental ballistic missile launched into orbit December 18, 1958, is shown high above the earth in this drawing by an artist of the Convair Division of General Dynamics Corporation, builders of the Atlas. The 82-foot missile, produced at San Diego, Calif., by Convair-Astronautics, is the only rocket in the western world capable of propelling itself into orbit around the earth. At left, still attached to the missile, is one of the three main engines which power the Atlas. Two additional "booster" engines were dropped at a lower altitude.

payloads into satellite orbit, or sending large instrumented probes deep into space.

Centaur will employ the Atlas as booster and a Convair-built upper stage of Atlas-type construction, powered by the first U.S. liquid hydrogen engines. If needed, the Vega third stage can be added for additional capability.

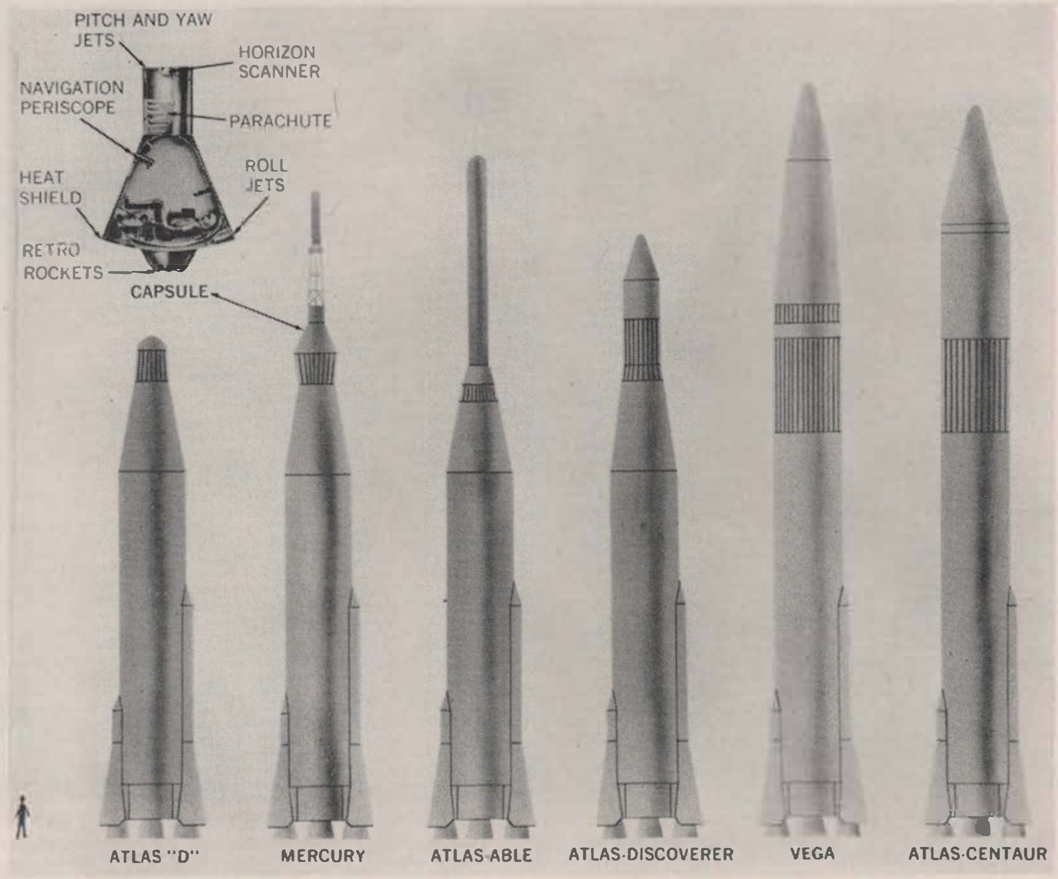
Contracts originally were awarded Convair and Pratt & Whitney Aircraft (a pioneer in liquid hydrogen propulsion) by the USAF Air Research and Development Command, as agent for the Advanced Research Projects Agency. The Centaur program was transferred from ARPA to NASA on July 1, 1959.

Krafft A. Ehricke, the noted space authority, is director of Convair's work on the Vega and Centaur programs.

Both programs rely heavily on Atlas technology, with resultant savings. In each case, the Atlas booster is being modified by building a tank of uniform 10-foot diameter (instead of tapering the forward end, as is done in the ballistic missile). Matching second stages are built of thin-gage stainless steel with Atlas tooling and welding equipment. New or modified Atlas complexes at Cape Canaveral will be used for launching both spacecraft.

Projects Midas, Samos—These are military satellite projects employing the Atlas booster and a Lockheed Aircraft upper stage powered by the Bell Aircraft "Hustler" engine. Both programs are sponsored by ARPA and directed by AFBMD. Lockheed is principal contractor, and Convair is responsible for conducting launchings from Atlas-type complexes.

Midas is a program to develop an early-warning system against enemy ballistic missile attacks. It is based on the use of satellites carrying infra-red sensors, to detect ICBM's immediately after launching. Samos (formerly



Sentry) is an advanced satellite reconnaissance system.

Atlas-Able 4—Atlas will serve as booster of this four-stage rocket, to be fired into space from Cape Canaveral. This is another in the series of Air Force "Able" shots, which are directed by AFBMD for NASA.

The second stage rocket is Aerojet liquid propellant (fuming nitric acid and UDMH); third stage, Allegany Ballistics Laboratory (spin-stabilized solid propellant, same as Vanguard third stage); and fourth stage, a Space Technology Laboratories vehicle having vernier control plus injection rocket. STL is program manager and associate contractor to AFBMD. Convair is responsible for the booster and its adapter section and for conducting the launching.

Future Application—The next generation of space boosters, to come into use in NASA programs of the 1960's, will provide thrusts on the order of 1 to 1.5 million pounds.

These include Saturn, a cluster of Atlas-type Rocketdyne engines, now under development for the Army Ballistic Missile Agency; and a 1.5-million-pound single chamber engine, also a Rocketdyne product (to be clustered in a super-booster known as Herax).

Centaur has been picked by the Advanced Research Projects Agency to serve as third (payload) stage of the Saturn vehicle.

Space Electronics—Convair's Azusa rocket tracking system, used for all ballistic missiles launched from Cape Canaveral, employs phase-comparison techniques for correctly positioning missiles with an accuracy of one-tenth of a foot at distances of 300 miles.

The system can be designed for handling deep-space communications at distances up to 200 million miles.

high speed computer elements

Ultra-high-speed, radically advanced electronic computer elements so fast that they can perform 10 million computer operations in the time it takes to say their name were announced here today by **Aeronutronic,** a Division of **Ford Motor Company.**

Known as BIAX, the new Aeronutronic computer elements are expected to become the principal components in the next generation of electronic computers—and result in faster, cheaper and much smaller computing equipment.

The new BIAX units are small rectangular bars of ferrite magnetic material so tiny that more than 310,000 will fit into a quart milk carton. More than 5,000 can be held in the palm of your hand.

BIAX can operate at a wide temperature range—from 260° Fahrenheit, or more than 50 degrees hotter than the boiling point of water, to Arctic temperatures well below the freezing point of water—in carrying out ultra-high-speed computing operations at millionths of a second.

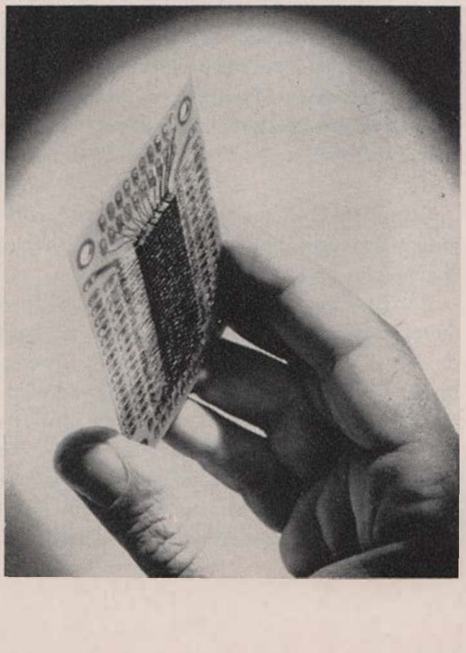
BIAX computing equipment will result in much lower cost computers, because the tiny, relatively inexpensive elements will replace expensive semiconductor devices such as transistors and diodes.

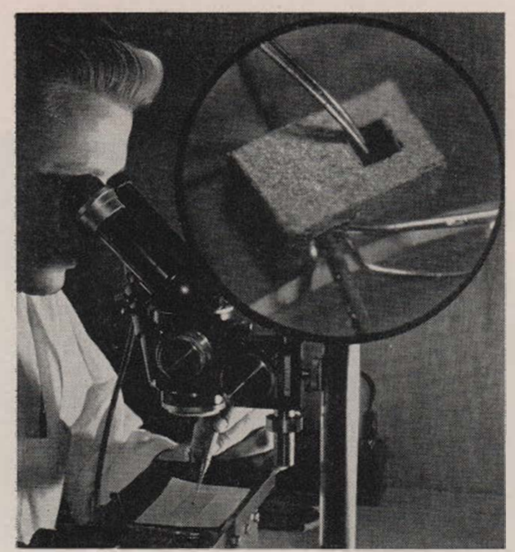
Two configurations of BIAX have been developed and are now being produced by mass production techniques. One is a "memory" element, and the other is a logic, or "reasoning" device.

Minuteness of the BIAX elements and their favorable environmental characteristics will make possible extremely small computer packaging, which is highly important in the space age. BIAX elements can be used in a number of types of computing equipment, for both military and commercial applications. Included among these will be missile and satellite installations, language translation, library

MINUTENESS OF BIAX is shown in this photo of several hundred of the new computer elements with a nickel. More than 5,000 can be held in the palm of your hand, and 310,000 will fit in a quart milk carton. BIAX is now in mass production, and complete BIAX memory systems and computers are now being marketed for special commercial and military applications.

A TYPICAL BIAX ARRAY for an electronic digital computer memory unit, this printed circuit card contains more than 300 BIAX elements. Multiples of such printed circuit cards, containing BIAX, are mounted adjacent to one another in a computer to provide large memory capability.





THIS ENLARGED microscopic photograph of a BIAX memory element shows details of wiring in the tiny, radically-advanced new computer component developed by Aeronutronic, a Division of Ford Motor Company, Newport Beach, California.

searching, de-coding, and scientific computation such as calculating flight trajectories for missiles and rockets.

In the forthcoming human-space experiments, BIAX elements will permit scientists to track "man in space" capsules with real-time calculations, and thereby determine the precise location of the space explorer at the exact time he is there. BIAX elements have a low electrical conductivity, and are not affected by radiation—making them highly effective for missile and space vehicle applications.

The BIAX concept and associated BIAX computer components were invented by Cravens L. Wanlass, director of research for Aeronutronic's Computer Operations, and are the result of a number of years of intensive study.

Complete BIAX memory systems and computers are now being marketed for special commercial and military applications.

Aeronutronic, formerly a subsidiary of Ford Motor Company, became a Division of Ford on July 1, 1959. Since its formation, Aeronutronic has had as its objective the development and manufacture of advanced products for military and commercial purposes in the areas of weapon and space systems, missile range systems and instrumentation, advanced electronics, data processing systems and computers.

cast optical silicon

Hughes Aircraft Company metallurgists have perfected a method of casting optical-quality silicon for use in infrared sensors in military weapons systems, Raymond B. Parkhurst, vice president, reported here today.

The new process permits volume production of silicon lenses, domes and flats. Until recently it was necessary to "grow" individual crystals for each optical element which, in turn, had to be laboriously machined before use.

Parkhurst reported that molds are designed to the approximate shape of the finished part and the castings given a final finishing on standard optical machinery. By holding castings to close tolerances, metal waste and finishing time is kept to a minimum.

"Designers can now specify silicon optics without worrying whether or not the necessary material would be available in quantity," Parkhurst said. "Using cast optics, manufacturers can plan on production rates equal to those of other optical manufacturing process."

Hughes engineers disclosed that there is no severe size limitation on elements that can be made. Infrared domes with an outside diameter of more than eight inches already have been cast successfully.

Two major difficulties faced the Hughes researchers in developing the process. First was the need for a refractory material that would withstand the high temperature and solvent action of the malten silicon. The Hughes laboratories investigated a number of different compounds and materials before finding a suitable one. Methods also had to be developed for melting the silicon under inert atmospheres, and pouring the metal into the mold. Fortunately the refractory material selected allowed the molds to be used again and again, lowering the cost of the process and making it more adaptable to mass production.

The second problem related to the optics of the cast part. Earlier it had been generally assumed that polycrystalline silicon, such as any casting process produces, would display optical qualities drastically different from those of single-crystal optics. But this has not proved the case. In test after test, no significant difference has been detected in the behavior of infrared rays as they pass through sections of the two materials. Physical tests indicate that the cast metal has exactly the same density as single-crystal silicon, showing that it is free of voids that would interfere on a random basis with the optical qualities.

vapor coating

Successful modification and improvement of a long-known process for vapor phase deposition of chromium, molybdenum and tungsten to produce adherent coatings of the metals on various substrate materials has been announced here by **Alloyd Research Corporation.**

Potential applications, utilizing chromium as a protective corrosion-resistant cladding, appear in the chemical, dairy and food industries as a low-cost substitute for stainless steel in valves, tubing and other equipment.

Promising electronic industry applications include coatings of certain components with high purity, high density tungsten to prevent contaminants in the base materials from adversely affecting the electronic emission characteristics. According to the company, by producing thicker "coatings" the possibility exists for fabricating thin electronic parts of refractory metals in this manner. Heavy coating of tungsten on graphite also appears possible for missile and rocket nozzles.

Qualitative bend tests of chromium coatings up to 0.005 inch thickness on copper and steel show no indication of cracking, spalling or flaking after extensive deformation. The same thickness of chromium deposited on copper gave complete protection to the base metal when immersed in a 20 per cent nitric acid solution during a test period of 64 hours. Compared with electroplated chromium, the Alloyd Research coating is nonporous, less brittle and does not risk hydrogen embrittlement of the substrate. Other advantages of the process include:

1. coatings of uniform thickness.
2. coatings that may be used at temperatures well above 300°F where plastic coatings for corrosion resistance fail.
3. coatings which can be applied to nonmetals such as glass and ceramics.
4. deposition temperatures can range from 700°F to 1700°F depending on the substrate material.
5. the process offers excellent throwing power permitting coating of complex shapes.

The Alloyd Research process is an outgrowth of a research and development program aimed at volume production of very high purity metals. Recently developed and improved chemical compounds of chromium, molybdenum and tungsten are credited in part for the success achieved. The company emphasizes, however, that the process is in the developmental pilot plant stage and is quoting interested organizations on this basis.

power transistor for military use

The production of a new military-type germanium power transistor, designated 2N297A, has been announced by the **Bendix Aviation Corporation.**

The rugged unit, which meets the military specification MIL-T-19500/36A (SigC), is the first of its type to be placed in production by the company, according to Dr. Robert R. Meijer, manager of semiconductor marketing of the Red Bank division.

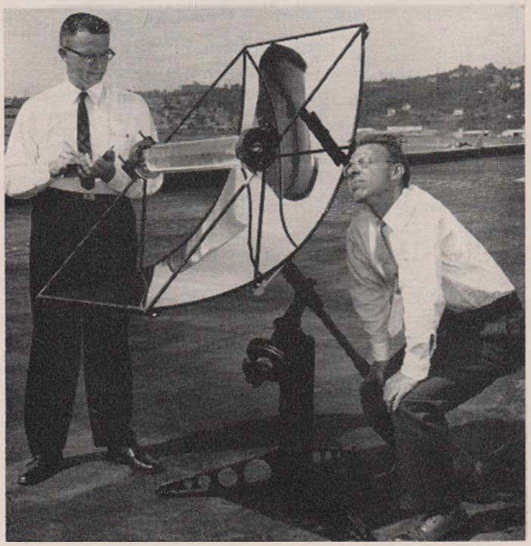
It can be used in numerous military applications, such as in missiles and supersonic aircraft, and also in many commercial fields for high-current switching, audio amplification, regulators, power supply circuits, and oscillator circuits.

The 2N297A has a maximum collector voltage rating of 60 volts, and a maximum collector current rating of 5 amperes. It has a dissipation of 35 watts at 25 degrees C. and 10 watts at 75 degrees C.

meteorites

THERMOELECTRIC GENERATOR OF BOEING-WESTINGHOUSE TEAM

A solar powered thermoelectric generator for tapping the energy of the sun is pictured being put through its paces on the roof of a Boeing Company building this week in Seattle. Developed jointly by Westinghouse engineer Niles F. Schuh (left) and Boeing engineer Ralph Tallent (sighting through telescope at the sun), the generator can convert the energy of the sun into 2.5 watts of power—enough

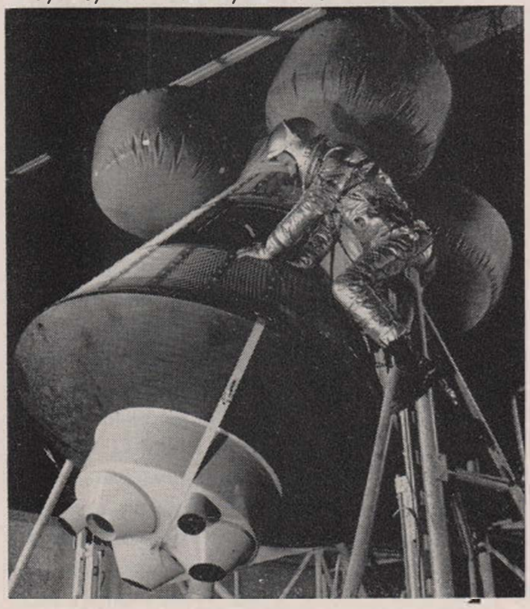


to power a radio transmitter far out in space. The model was demonstrated at the summer meeting of the American Institute of Electrical Engineers. Boeing and Westinghouse said the generator may have application in long-mission satellites and manned space vehicles of the future. The concave, highly polished reflector, which resembles a "fun house" mirror, collects the sun's energy and concentrates it on a portion of the cylinder shaped generator in front of the reflector.

—Boeing Airplane Company Photo

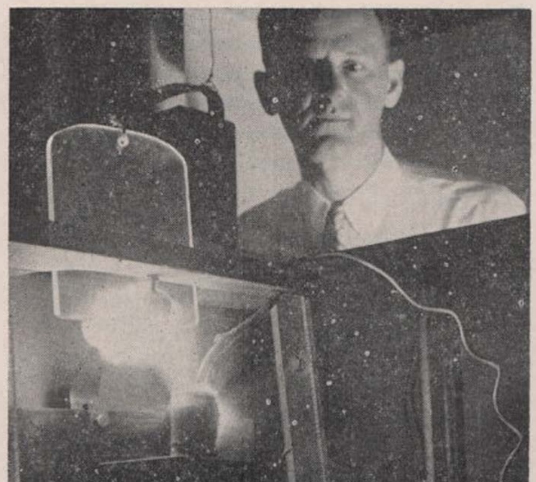
CAPSULE AND ITS CARGO

The first view of the **McDONNELL SPACE CAPSULE** mockup to be released publicly shows a pilot preparing to climb through the entrance hatch of the manned satellite being built for the National Aeronautics and Space Administration. This picture taken at the **McDonnel Aircraft plant** in St. Louis provides a good view of the retro-rockets (lower left) and the flotation bags which give the capsule bouyancy and stability in water.



SHELTERED LAUNCH—Proving a jet fighter can take off from a shelter designed to withstand an atomic blast, an Air Research and Development Command F-100 Super Sabre completes a Zero Length Launch (ZEL) at Holloman AFB, New Mexico. **North American Aviation** Test Pilot Al Blackburn, Los Angeles, Calif., was at the controls.

'SPARK BOMB'—A flash of man-made lightning triggers an underwater explosion that bulges an aluminum tube with 6,000-horsepower force! In this demonstration of explosive forming of metal at **Republic Aviation Corporation** (Tues. Sept. 1) the experimental device sets off the explosion by passing electricity through the water, converting the resulting shock wave into the force required to form metals. Adolph Kastelowitz (shown watching the blast), director of manufacturing research for the company, said it is working on development of a machine tool that would utilize this technique to form such space-age metals as steel and titanium alloys. Such a tool, he said, would be less expensive and considerably smaller than conventional hydraulic presses now used for this work.



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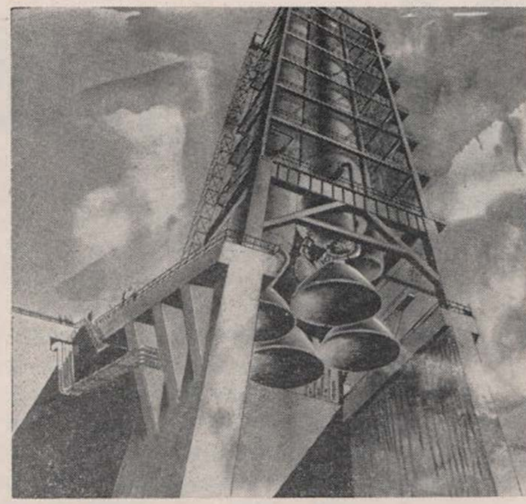
ION TEST—Prototype ion thrust device, developed by Rocketdyne, a division of **North American Aviation, Inc.,** produces ion beam during test run in vacuum tank which simulates outer space conditions. Thrust system, in which ions are created and accelerated to high velocities, is visible at left. The photograph was taken through a port in the top of the vacuum tank. An ion engine delivering only a fraction of a pound of thrust could propel space vehicles on interplanetary voyages.



AEROJET DESIGNING GIANT ROCKET TEST STAND

Shown above is an artist's conception of Aerojet's giant six-million-pound-thrust rocket test stand. It is comparable in size and scope to the one presently being designed by the **Aerojet-General Corporation's** Facilities Engineering Division for the U.S. Army Corps of Engineers. The stand will be constructed at Edwards Air Force Base and used for testing the NASA 1,500,000-pound-thrust liquid rocket engine. This concrete and steel test facility, believed to be the most powerful in the free world, will be capable of holding a cluster of four of these engines while they are being fired simultaneously.

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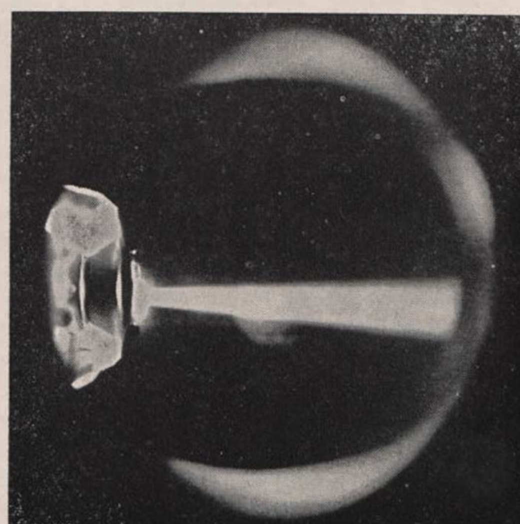

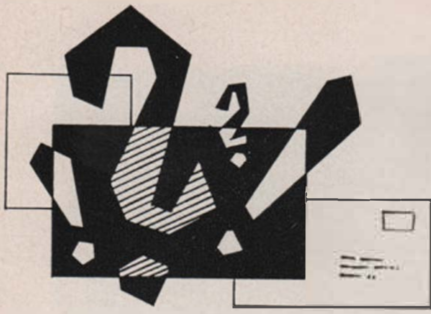

reaction

Dear Editor,

Although Space Journal is a young magazine, I feel that my letter is old or late, or both. Your publication is filling a basic need, that is supplying the latest information on rockets and space travel to those who have a need for such information. The biggest problem is to create enthusiasm and interest in the magazine to the readers. This can be accomplished by having the magazine available to those most closely affected by space. Where I'm employed there are a respectable number of us employed in rebuilding rockets, but I can count on my fingers those who are genuinely interested in rockets and rocket development. I think its a crime that this situation exists, particularly because of the terrific waste of tax money due to this disinterest, but the free-loaders and goldbricks sure do put on a good show. Astronautics is such a fascinating field that this condition just doesn't make sense.

The following is a suggestion as to how you may help rectify this situation. A few months ago I took a few copies of Space Journal along to work. Some of the men began to show some interest. My suggestion is for you to donate to our section a copy of Space Journal, perhaps for a year. A magazine such as yours coming to us with the compliments of the editor will make the men feel just a little more proud to be in the missile program.

The following are a few ideas I'd like to see in Space Journal.

1. A list of books available on Astronautics and the Sciences.
2. Diagrams on propulsion systems and airframes.
3. Articles on components (Regulators, Gyros, Relief Valves, etc.)
4. Job availability for missilemen.
5. Technical information of foreign rockets.
6. Running course in Astronomy and propulsion units.
7. More technical information.
8. More detailed articles on the problems of space travel and development.

I hope my suggestions will help.

Letterkenny Ordnance Depot
Electronics Branch
Guided Missile Section

William Hough
Chambersburg, Penn.

Your suggestions can do nothing but help, Mr. Hough. What our missile program needs is a thousand more William Houghs'. We hope the copies of Space Journal will help. Thanks for letting us help you. Editor

Dear Editor,

If the articles I have been reading in the newspapers are for the most part correct, and we are behind the Russians as much as five years, I have a question that may not be to your liking. What are you so complacent about? Your last editorial was a milksop!! You have yet to take a stand on any vital issue. You either don't believe that the United States missile lag is dangerous, or you don't care!

I will do you a favor if you will do me one. I will continue to read Space Journal if you will put some editorial guts in what is otherwise a fine publication.

If toes in Washington need stepping on, then let them have it. There must be some member of your staff who is not afraid to call a spade a spade. I have spent most of my life in the federal service, and am presently at Vandenburg Air Force Base. If I will risk my neck for you, is it too much to ask that you quit hiding behind the metric system.

Vanderburg A F B (name withheld)
Lt. Col. USAF

We have no defense, but will try to improve with age. Thank you for a frank letter. Editor.

free information

Editors note: Information will be supplied on any of the items listed below. Write to Editor, SPACE Journal, 316 Howerton, Nashville, Tennessee.

PIC Design Corporation, a subsidiary of Benrus Watch Company, Inc., is offering, upon request, copies of their new, 416-Page Master Catalog No. 20a.

This catalog has been printed on special custom-made "Bible-Leaf" paper to reduce valuable file and drawing board space. Consolidating all previous catalogs and supplements, the new catalog lists over 10,000 items, including gears, shafts, collars, couplings, speed reducers, differentials and other precision items available from STOCK.

In addition to detailed drawings, complete specifications and prices, the new catalog contains separate Technical Data, Breadboard Kit and Precision Tool Components Section.

A new **1959 Catalog of Aviation & Technical books** is available free-of-charge from Aero Publishers.

Described in this 36-page catalog are books of all publishers, including the Government Printing Office, on Jets, Rockets, Missiles, Space Travel, Engineering, Piloting, Aviation History, Maintenance & Production, Electronics, Flight Operations, Logbooks, Mathematics, Model Building, Nuclear Energy, Meteorology, Navigation, and just about anything else pertaining to aeronautics and its allied industries. Some navigation computers and other pilot supplies are also listed.

The United States Air Force has contracted with **Callery Chemical Company,** Pittsburgh, Pa., to supply HiCal, a boron-based high-energy fuel, for a classified military project.

Delivery of the fuel will begin immediately from the firm's Lawrence, Kansas, plant. The entire production of the plant has, until now, been utilized by the Navy. The plant went onstream last fall.

Callery has also announced that HiCal will soon be available to aircraft, missile, and rocket manufacturers for evaluation in engines and components.

HiCal can be shipped under ICC regulations in specially-designed cylinders.

Information on handling the fuel is available.

The Research Chemicals Division of **Nuclear Corporation of America** now has available a revised price list of the rare earth oxides and salts used in varied research for military and institutional purposes. Dr. Eugene V. Kleber, who heads the Division, noted that the prices of a number of the purified rare earths are greatly reduced.

Successful development in the laboratory of a new vacuum "plating" process which will deposit a tightly-adherent, decorative and corrosion-resistant coating of pure aluminum on a wide range of base metals from high tensile and mild steels to aluminum die casting alloys has been announced by the research division of **National Research Corporation.** The ductile, non -porous coatings may be anodized to provide excellent wear resistance as well as attractive coloring in a full spectrum of metallic pastel and dark shades.

Potentially large-volume applications appear in several industries such as the automotive field for both exterior and interior bright or colored trim and in household appliance manufacture for decorative purposes. Other potential applications include aircraft and missile parts and marine hardware.

Aircraft interest in corrrosion-resistant aluminum coatings stems in large part from the fact that most previously employed organic and metallic protective coatings will not withstand temperatures above 500°F and are frequently subject to chemical attack from some fuels and insulating materials. A large airplane manufacturer has tested NRC aluminum coatings for periods up to 1,400 hours in 20 per cent salt spray and salt fog without failure. Laboratory tests indicate hydrogen embrittlement of high tensile steels encountered in conventional electroplating of aircraft and missile components for corrosion protection is eliminated in the vaccum coating process.

Preliminary estimates for vacuum plating show that process costs on a commercial scale should be competitive with conventional electroplating for a number of applications.

Additional information available.

books

The Impact of Air Power. Edited by Eugene M. Emme. Van Nostrand. 914 pages. $12.50.

This book is intended to be a comprehensive and annotated volume of readings from a wide range of informed sources. Although the era of air power is still in its infancy as far as time is concerned (a scant fifty years), yet never in such a period of time has the course of history past and to come been altered so completely.

This book attempts to make clear the problems created by air power as an instrument of national policy and by its influence upon national security.

Although most of the book was compiled before Sputnik I, the thesis of the volume is well confirmed. Air power has been made more complex by the rise of ICBM's, but the prominence of air power is no more tied to any one type of air power than sea power is tied to sails. Air space and outer space are a single and indivisible medium.

The book is divided into three parts. A brief account of the parts would show:

Part I—The Nature of Air Power—which includes (1) The Evolution of Air Power, (2) The New Mobility.

Part II—The Revolution in Warfare—which includes—(1) Classical Theories of Air Warfare, and (2) World War II, (3) Lessons of WWII, (4) Small Wars and (5) Future Wars.

Part III—(1) Soviet Air Power, (2) American Air Policy, (3) Air Power in Europe and Asia, and (4) Astronautics.

High Altitude and Satellite Rockets. A symposium. 136 pages. Philosophical Library. $15.

This volume is a collection of the papers presented at a symposium sponsored by the Royal Aeronautical Society, The British Interplanetary Society and the College of Aeronautics held at Cranfield, England, 18th-20th July 1957.

Presented before the Russians launched their first satellite, the twelve papers are of interest because of the nature of the problems they deal with in detail. Ranging from propulsion problems of high altitude rockets, recovery after re-entry, high temperature materials, instrumentation, telemetry and guidance and some of the advanced technical problems to the very human problem of what to do with man in space and how to keep him alive.

Realities of Space Travel. Selected Papers of the British Interplanetary Society. Ed. By L. J. Carter. 431 pages. McGraw-Hill. $7.50.

Especially noteworthy is the section of this book that is devoted to the research being done on the "weight condition" man will undergo when he rockets into pure space. The papers cover methods of air purification, the use of algae for food and atmosphere control, and how the length of time projected for the individual trip will affect and control the food requirements of the space traveler.

The book also covers in detail other aspects of astronautics-aerodynamic braking, escape velocity, testing of rocket performance, cosmic rays, limiting factors of chemical rockets, and others.

The engineering problems are discussed in concise and simple terms. The data in the book will be of interest to the scientist, engineer, or researcher interested in this field.

Nuclear Rocket Propulsion. By R. W. Bussard and R. D. DeLauer. 375 pages. McGraw-Hill. $10.

This book presents to the engineering man a sound basis for understanding the engineering problems of mobile reactor systems, problems that cover such areas as heat generation and removal, fluid distribution, and flow and structural integrity of the rocket itself. The authors' presentation is primarily descriptive: the fundamentals in each area are given without extensive mathematical proofs, but realistic physical bases are provided for all analyses.

The book surveys the fuel elements, moderators, control elements, and structural materials of rocket reactors in the light of how they affect and control the type of material used in the nuclear reactor. Some of the materials discussed are graphite, tungsten, molybedenum, tantalum, niobium, rhenium, and the refractory borides, among others for their potential use for high-temperature-reactor fuel elements.

As a source of information about the fundamentals, Nuclear Rocket Propulsion is very timely in this rapidly growing field.

The Prediction of Ballistic Missile Trajectories from Radar Observations. By Irwin I Shapiro. 208 pages. McGraw-Hill. $7.00

This book develops methods, based on the statistical theory of parameter estimation, that can be used to determine ballistic missile trajectories.

With very slight modifications, the methods can also be used to determine the osculating parameters of satellite orbits.

The information upon which the estimates are based is obtained from observations of the missile by monostatic radars located at one or more sites.

The method given prime consideration is the method of maximum likelihood.

Several different procedures, appropriate for different practical situations, are described which can be used to find explicitly the maximum likelihood parameter estimates.

An extension analysis of the random errors associated with predictions based on the maximum likelihood method is also given. Such an error analysis provides a good approximation to the maximum predication accuracy obtainable for systems containing monostatic radars.

Several chapters cover the changes in the predictions methods necessary to account for the earth's oblateness.

The appendix include: Iterative Solutions to the Kepler Equation and An Error Analysis of Milne's Method.

space focus

Move of ABMA from Army to NASA—

President Eisenhower. "The contemplated transfer provides new opportunity for them (ABMA to contribute their special capabilities directly to the expanding civilian space program."

Werner Von Braun, Technical Director, Army Ballistics Missile Agency, "the President has decided that it is in the best interest of the country that our work be continued within the framework of the National Aeronautics and Space Administration. Since NASA's establishment a year ago, we have worked harmoniously with that fine organization.
We look forward to a continuation of our efforts with NASA in a progressive space program which will make this nation second to none."

Major General John B. Medaris," I am both pleased and relieved by the President's decision. It will stabilize the situation and the mission of the great development organization I have had the honor to command since its activation Feb. 1, 1956."

On Polaris Missile—

Admiral James Russell, Vice chief of Naval Operations," despite all the miliary value one finds in the *POLARIS* submarine system, I would not advocate having it as the only retaliatory system. A single system can be met with a single countermeasure, and although the countermeasure against the *POLARIS* is not now evident, in consideration of it we should have some variety in our retaliatory locker."

On sustaining man in space—DR. RUSSELL O. BOWMAN, CHANCE VOUGHT space medicine man, is conducting experiments to find out how man can breathe and eat while on space trips. Answer: Algae probably. Two white mice lived in sealed jar—algae provided the mice with oxygen, mice sustained plant with carbon dioxide. Food pellets was thriving diet for the mice.

On motivation for public support of space programs—"Scientific curiosity, the basic human urge to investigate the unknown, the lure of outer space as a limitless scene for high adventure . . . offer only flimsy basis for the sort of large-scale collective enterprise that a space exploration must be," asserts DR. SIMON RAMO. "The promoter of a particular space project . . . had better be prepared to argue pretty cogently that his project will yield the public either some impressive military advantage or else some economic return that outweighs the cost. Group survival, or else comfort and convenience, are the substantial group motivations he must enlist in support of his personal enthusiasms . . . The program must appear to do so, and the facts must on the average fit that appearance."

On timetable for man on the moon—Present technology with adequate support can put man on the moon between 1980 and 1985, according to the timetable of Y. C. LEE, AEROJET-GENERAL spaceman. First step will be made this year as the X-15 goes out 100 miles for reasonable length of time to explore environmental effects. Then, man can go into orbit (220-300 miles out) for a couple of times via Project Mercury in about two years to determine reactions on sustained flight. Then: 1965-70, man in orbit for indefinite time with capability of return; 1970, instrumented orbit into real space, 20,000 miles or more to study influence of moon's gravity. 1980—orbit man around the moon for first hand observation and provide return capability or space platform. Then, man will be ready to make his first landing.

On life on other planets—Discovery of life on other planets would be one of the most momentous events of human history and next to synthesis of living matter in a laboratory, the most important step that could be made toward an understanding of the problem of the origin of life, according to DR. ALBERT ROACH HIBBS of CALTECH'S JET PROPULSION LAB. "Telescopic observations show large scale chemical processes involving carbon are taking place on terrestrial planets," he revealed . . . Other possible origins of life on other planets: Panspermia—the scattering of life-bearing seeds through space so that they fall on planets and germinate where conditions are favorable. Spontaneous Generation—at the molecular level. Unmanned vehicles to Mars can radio back information on the chemical constituents of life there.

Marquardt—**(cont. from p. 9)**

and feasibility studies on Air Force Project Pluto, in conjunction with the Lawrence Radiation Laboratory of the University of California.

Marquardt is sure that further studies will show that a nuclear ramjet can carry a larger payload through the atmosphere at less weight and cost and without the shielding problems inherent in other systems.

While Marquardt holds a virtual monopoly on ramjet development and production, his company's interests extend deeper into more advanced, sophisticated propulsion systems.

"Yes, we're working on electrical propulsion research," Marquardt declared. "Our ASTRO—Air-Space Travel Research division—actually is studying many propulsion systems for space vehicles and carrying out research projects dealing with aerothermodynamics, magnetohydrodynamics, combustion, fuels and propellant combinations."

In discussing electrical propulsion, Marquardt pointed out that the principal actually isn't new.

"The cathode ray tube in a television set is an ion accelerating device," he explained.

The big problem in space propulsion: "We have to figure out how to generate the electrical outlet in a system to get the power to accelerate the choice particles. You need an electro magnetic field to harness the ions."

But it's not insurmountable. Marquardt predicts electrical auxiliary power will be ready in a few years.

"The military application will come the soonest," he stated. "In a few years, we will be able to provide electrical propulsion for course correction and orientation of reconnaissance satellites. The military is going to have to pinpoint the satellites in the right direction."

Primary electrical propulsion will come much later he feels.

Primary propulsion for true space flight will come after we develop space platforms.

Theorizes Marquardt: "Electrically powered space ships probably will have to take off from space platforms. We must launch them —the space ships—from space."

"A very small amount of thrust is very efficient in outer space," he noted. "Electrical propulsion will provide an infinitesimal thrust for infinite times from such platforms."

Roy Marquardt, now just in his early forties, is an acknowledged leader in the development of non-conventional propulsion. He founded the Marquardt Corporation at the ripe young age of 26 to put his ramjet propulsion concepts to work.

His interest in ramjets was sparked in 1942 when, as engineer in charge of naval research at Northrop Aircraft, Inc., he was assigned a research program to delve into methods of cooling engines mounted within the wings of an airplane.

Two years later he accepted an appointment as director of aeronautical research at the University of Southern California to pursue the ramjet development concepts which the Navy was sponsoring in a program for a subsonic ramjet at USC.

Marquardt organized his own company to provide the development and manufacturing requirements for that program.

In his 20 years in aerospace pursuits—half his life—Roy Marquardt is credited with multiple achievements in the field of supersonic propulsion which led to the development of the supersonic ramjet as a production powerplant for the Air Force air defense Bomarc interceptor missiles.

He took both his Bachelor and Master of Science degrees in aeronautical engineering at famed California Institute of Technology. During his graduate work, he held a teaching fellowship, giving him a rounded academic, engineering, business background rare in one individual.

Roy Marquardt's interest in air and space technology began, however, long before he entered Cal Tech.

Nearest he can remember he was about nine when he took his first flyer in the world above—in a small scale. Inspired—as were many youngsters—by the era of the heroic, historic flight of Lindbergh in the first trans-Atlantic solo—young Roy turned to building model airplanes—avidly.

So great was his enthusiasm that he soon flamed the spark for the hobby in many of his school friends. And in so doing he created his first business venture.

His hometown of Burlington, Iowa, was just too small to provide the supplies for so sophisticated a hobby as model airplane building. Roy and his friends were faced with a 100-mile journey to get their supplies.

With the ingenuity that was to spark his career, Roy set up a model parts depot at the YMCA, stocking kits in a locker and selling them over the counter. He expanded by organizing classes in model airplane building—thus creating an even greater market by initiating more novices.

Thus, out of his appreciable profits, he supported his own hobby.

In the step by step chronology of moving ahead in successive steps, Roy turned to gliding by forming a club and building a glider with his friends. A Model A Ford towed the glider to the then fantastic speed of 50 mph. And Roy logged 40 flights.

"This early business background has been a great help," he noted. "I was keeping books by the time I was 12 to show what people owed me, and I developed a healthy respect for the business side of any venture."

However, his model airplane trophies which he keeps in his collection are obviously still his greatest point of pride.

Thus, in his earliest years—Roy Marquardt's destiny was forming. Today he is aiming his company's efforts higher and higher, just as he did his own in boyhood.

With his eyes focused on space, he is building his company to take part in the great adventure possible. In addition to strengthening his firm's capabilities to meet space technology demands head on, he expanded it still further last year by acquiring the Cooper Development Corporation as a wholly owned subsidiary.

Cooper provides the knowhow in solid rocket development to complement Marquardt's own capabilities.

The subsidiary played a prominent role in the International Geophysical Year by providing rockets and components for high altitude weather and atmospheric soundings, studies of solar phenomena, particulate samplings and final stages of propelling satellites into orbit.

The subsidiary is now into the second phase of Project Sun Flare. It is boosting 50-lb. payloads in 1760 pound Nike Asp rockets to further study of solar phenomena under the direction of the Naval Research Laboratory. The ASP vehicles are Cooper developed.

Today, the Marquardt Corporation stands out as a leader in the exciting field of space technology. The credit goes to its founder.

HYPOTHETICAL HIGH MACH NO RAMJET TRANSPORT

Roy Marquardt has come a long way from the air-struck youngster who built powered airplane models. But every step he has taken since he was nine years old has led him to his present eminence and prepared him for the many contributions he is yet to make.

Joining his collection of childhood honors are the citations to a engineer-businessman. He was named the "Outstanding Engineer of 1958" by the San Fernando Valley Chapter of the California Society of Professional Engineers and this summer was saluted by the Los Angeles Chamber of Commerce on the 15th anniversary of his company. He is a Fellow and former vice president of the Institute of the Aeronautical Sciences, a Fellow of the American Rocket Society. He also is a member of the Society of Automotive Engineers, American Ordnance Society, American Society of Mechanical Engineers, American Helicopter Society and the Young President's Organization.

Brainy, friendly and articulate, Roy Marquardt's eyes are on the future as he guides his company into the space age. And he sounds like a man who knows where from he speaks as he affirmatively concluded:

"The ramjet is not through by a long way. It's full potential is yet to be realized."

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weightless man

future, Space platforms circling and surveilling the surface of Earth, and even Lunar bases. And there *will be* the weightless man floating through interplanetary Space.

Let us imagine, now, that you are a passenger on one of these Space ships. Without getting too deeply involved in physics, you may ask what happens when you find yourself, say, practically outside of the gravitational field of Earth. You are weightless, but does this mean that you are also free of any pull of gravitation? Of course not, because the gravitational force of the Sun and other stars is still acting on your body, accelerating you along an orbit akin to that of a celestial body. This condition may be thought of as a free fall through Space, with no other forces felt than those within your own organism, moving in a curving path that eventually ends in the center of the mass or masses that attract you. There is no difference between the biological effects of weightlessness encountered in this mode of travel and the one experienced in a parabolic flight within Earth's atmosphere.

Let us continue to imagine you are in a Space ship going to the Moon. First of all, the various propelling, cooling, and cycling systems must be so constructed that they con function properly in zero-gravity. That is, no free-foll or weight factors will adversely effect any portion of the equipment. We have had some unfortunate experiences in our zero-gravity flights: after a few seconds of weightlessness, both fuel and oil pressure went back to zero. Mechanical pressurization of the fuel tank and a closed lubrication system will be necessary to remedy this disconcerting situation. Furthermore, the Space ship designer must know how various materials behave under gravity-free conditions: gases do not rise; for instance, there is no exchange due to differences in specific gravity, but dust and all unsecured solid objects may float and settle everywhere; and liquids tend to assume spherical shapes. These factors have serious effects upon many a conventional instrument and apparatus design.

Naturally, all things in the Space ship must be held in place, and this goes for the traveller, too. Without a restraining harness you will float out of your seat upon a healthy sneeze. Since you already lost your feel of being supported, the harness should be of the full-bodied type, even covering your lap and pressing you gently in your seat by means of elastic strings. If you should inflate your pressure suit while you are not secured in your chair, it will give you a false feeling of support and propel you upward so that you bump against the overhead. This then leaves no doubt—even if you are floating freely in the cabin—about which is up and which is down. There hardly exists the need for a special means for orientation other than adequate lighting inside of the ship.

Since visual reference is the most valuable means of orientation in zero-gravity, the eye functions must be maintained under all circumstances, particularly during the weightless condition. However, as long as the eye functions properly, the loss of the gravitational direction is not alarming, for the interior of the Space ship should be so constructed that the seats, head rests, table tops, floor and ceiling of the cabin, etc., will always indicate the directions up and down, as do the respective parts of our body. This directional arrangement, though valid only relative to the vehicle, will still be convenient and practical, for it sustains that frame of reference to which man on Earth is accustomed. For this reason everything within the ship will be as familiar, simple, and functional as possible. There will be beds, washrooms, recreation facilities, and provisions for nutrition and elimination. From this vehicle, an improved version of the modern airliner or submarine, you will have a new look at the old world: you will see Earth as one of the stars.

This weightless flight to the Moon is not just another creation of fiction and fantasy. It is based on our own experience during the many parabolic flights which, a few years ago, were thought to be impossible and as fanciful as flight into outer Space. But we flew, worked, ate, drank, and tried the means for human comfort in the gravity-free state ourselves; and we now translate our experience into common terms, and project it into a realistic future.

As a result of our experiments we know that care must be taken for the well-being and safety of the passenger. The seats probably will be of the reclining type, adjustable in position and angle, and easily converted into a bed. Hammocks are impractical in a Space ship, because they would tend to float at every move you make, and they may start swinging rythmically with the beat of your snoring. The sleeping bag with a zipper on top, attached to your chair, will hold you down very softly at night, and may prevent wild dreams and feelings of terror, which could be otherwise brought about by the unconscious sensation of lost support. As a matter of fact, your sleep may even be sounder in the weightless state than under normal conditions, since your posture of rest is naturally associated with a shift in weight distribution in your body and its main points of support.

If you wish for breakfast in the morning, the Space stewardess will simply push the tray over to you. It then drifts through the air as though passed by a ghost servant. It is made of plexiglass and shaped like a box in order to hold its contents together. Inside there are compartments with cereal, slices of bread, spray cans with coffee, juice and cream, tubes with butter, honey, fruit jam, and fresh fruit at your disposal. Of course, all liquids are kept and served in squeeze bottles, because one cannot drink from an open container in the weightless environment. Experiments on eating and drinking during parabolic flights have shown that the liquid floats out of the glass and hits the face with a splash just by lifting the container; thus it is possible to drown in your own cup of coffee because the liquid disperses upon contact like at an explosion and slips into your respiratory tract with the whiff of a breath.

You won't have to adjust your seat from the sleeping to the sitting position, for the tray is not going to fall off your lap. Thus, you will bring up your knees to anchor your breakfast tray, open the lid on your side, and start preparing the food. You reach inside, squeeze the contents of your butter tube on the freshly toasted bread so that it sticks, distribute it without any difficulty, for you have already learned to control your movements, and spray a layer of honey on top, taking care not to let it float too high up, because it may be glued against the cover of the buffet box. Then you take the coffee bottle from its holder, open it carefully so that nothing floats out, put some lumps of sugar in, squeeze in some cream, shake and mix the ingredients and then press the button while holding the container between your lips. You can chew and swallow without much effort, because both activities are not affected by the lack of weight. The elastic forces of the peristalsis take care of the rest and transports the food through the body. It's better to have your eggs boiled rather than fried or scrambled, because the latter procedures may prove somewhat difficult. We still are working on a frying pan that would do the trick. Boiling seems to be easier. If you don't shake your electric cooker, which has some special features to be patented, you can boil things in it without trouble. Handling medium boiled eggs may be somewhat messy, you would do well to ask for the hard ones which you can chew, or the soft ones which you can suck out of the shell.

You may not have to go to the restroom so often as on Earth since the contents of your stomach, intestines, and bladder are weightless and will not trigger so easily the reflexes that give you the feeling of an urgent need. But getting off your chair demands some caution. First, you will press your suction type shoes against the floor, get out of your harness, keep your hands on the rail and move slowly, bit by bit, to the restroom door.

Once in the restroom, you are confronted with another problem. You must rely on closed and sealing containers for your relief, which withdraw and seal whatever leaves your body. Waste bags will be available for this. The lavatory facilities are already a headache on our present-day airliners; and in a Space vehicle the commodities most probably will be under par. Washing your hands can be accomplished only in a transparent water sack. You will stick them through two elastic rubber valves which seal your wrists, push the water inlet pressure button, the soap squeezer, clean your hands, and finally force the water out by a suction pump. During all these maneuvers, your feet will be solidly held to the floor by a mechanical device. You dry your hands on a towel and store it properly. As to the elimination of all waste products, it must be done because of the hygiene and comfort of fellow passengers and done with respect to mass alterations within the ship, which might be brought out of course or orbit.

Hence, not all of the trip is pleasant. Take Johnny, for instance. He is slowly turning pale and green in his corner; and his father has already signaled to the stewardess that something is wrong. About 20 percent of the passengers in our parabolic flights became sick; and females and youngsters will probably become ill with gastro-intestinal symptoms during weightlessness, if the present statistics on motion sickness hold true for Space sickness. By swaying, floating and moving about, one arouses the perceptual mechanisms that register the position, motion, and support of the body under both weight and nonweight conditions. Now, under the latter, the sense organs for maintaining equilibrium and orientation send signals which actually confuse the Space traveler to his brain. Thus, he vomits and has some trouble catching everything floating around and storing it in the "burp" bag.

Our pilots are hardly ever plagued by this type of Space sickness. They have been exposed to weightlessness and changing accelerations so many times that they are familiar with it. They have their instruments which indicate the vehicle's position and attitude relative to Earth.

Our pilot has been fired into the air; and is now supervising the instruments which guide the ship along its predetermined course. On one hand he is completely on his own; but on the other hand, he is not. He cannot leave or land his ship in case of emergency because he is beyond his point of return. He must make it or ask for help from the base to which he is steering. He will be told from there what to do. In this stage of the flight, there is no input or feedback of the controls. As a matter of fact, monitoring and firing of the gimbal-mounted steering rockets have nothing in common with the conventional type flying. He calmly checks his instruments; everything goes as programmed. He is now flying with the cockpit extended; it was telescoped inside of the hull during penetration of the atmosphere. There is no flying by the seat of the pants during weightlessness, nor any sensation of lift or drag on the ship. As a matter of fact, his control surfaces are idle. Gliding through Space is nothing but a push-button affair and an eerie kind of locomotion. For landing on the Moon he needs little more than his brake rockets. This will stabilize the ship and restore the weight. Only when he plunges back into Earth's atmosphere will his flying skill be required.

Moon is now just in front of the vehicle. You look up from your journal which hangs in the air by itself with the pages extended, slowly drifting away in the stream of circulated air, and listen to the announcement over the intercom giving the ship's latest position. The picture on the television in the passenger compartment shows the Moon's huge, bright, Sun-lit cap on the velvet-black background of the star-speckled sky. There is no sensation of motion, and you—resting in absolute weightlessness—have the feeling of being suspended in between these un-blinking stars. The radio is silent; and only the soft hum from the vents which circulates the air inside of the cabin is still audible in the silence of Space. You feel physically relaxed, but otherwise somewhat uneasy in this seemingly unreal situation. The stewardess removes her cap, and her long hair stands straight up, slowly drifting back and forth in the air stream of the recycling fans. Your hands start sweating. So you pull the sprayer from your bag, wet them with cologne, and wipe it off with the handkerchief. Then you take a cigarette and snap your lighter in vain, and—forgetting where you are—you try it again until it occurs to you that no flame will burn in zero-gravity. Therefore you ignite the cigarette with the electric lighter and puff, completely unconcerned about the possibility of dropping the ashes.

The end of our make-believe trip brings up an important point: the conditioning and training of future Space travelers. Elaborate propulsion and training devices have been suggested by experts for training the crew and passengers. They are based correctly on the assumption that man must be adapted to the zero-gravity condition and to the sensation of weightlessness. They should also be exposed to increasing and decreasing accelerations in order to adjust their feelings, coordinations, and performances to the effects of changing weight.

In this respect, it is apparent that the best training available now will be achieved by parabolic flights in high-performance aircraft. Such flights will serve a double purpose. First, people who cannot stand the weightless condition and the changing accelerations associated with rocket travel will fail; and they will have to postpone their trip to the Moon until other modes of travel are available. Second, the ones who can stand it become conditioned and used to weightlessness, as well as to the means which protect them against potentially adverse effects of prolonged periods of weightlessness. We know that a man will fall to his death if he loses his balance at the rim of the Grand Canyon;

but instead of trying to increase his tolerance to falling, we provide him with the means which help him to prevent the accident. This principle must also be applied to the weightlessness associated with Space flight. An appropriate harness, foot rest, fixtures to put himself and his utilities in, suction-type shoes, handrails, and safety ropes will prevent floating and involuntary movements of objects; and he must be trained in the skillful utilization of such devices for comfort and safety. The construction of these devices is no serious problem once we know what is going on in zero-gravity. We do a lot of things where we can fall and hurt ourselves: climbing on roofs and trees, riding and jumping on horseback, playing football and driving a car at high speed, creating enormous accelerations which often lead to fatal accidents. We must not forget that weightlessness is a physically stressless situation which in itself does not involve any bodily harm or danger. If we observe the necessary precaution and adapt ourselves to its characteristics, it will provide us with luxury and pleasure not normally attainable on our planet.

However, our Space travelers must be schooled in the readaptation to gravity from the weightless state. We do not expect too much difficulty with this either, because this should even be more easily accomplished than his adjustment to zero-gravity. We are accustomed to the gravitational force from birth, and we will snap back into it with ease and regret. To the seasoned Space man the return to Earth and its gravitational field will be a return to his original and familiar state.

space food (cont. from p. 12)

In actuality this idealized plan may resemble only remotely the system finally put to test in long and ever longer Space excursions. But recent research in several fields has indicated that the man is likely to be both the weakest and the least readily changeable element in the closed-cycle system.

Selection and preflight training will make significant contributions to the crewman's successful Space operation; but, fortune being what it is, he is still a man and as such must be maintained within rather narrow limits of pressure, temperature, humidity, pH, and nutrition even to stay alive. And for him to perform optimally, the limits must be moved still closer together.

On the other hand, the remaining components of the system are not so rigid.

The algae provide a fitting research subject mainly for taxonomists and photosynthesists, with a brief interlude of intense interest in their introduction as a field crop to be competitive at least with other animal feeds.

In this melee, there has been but little attention given to the physiology of the algae and practically none to their functional characteristics such as the production of oxygen or to their expected behavior in a small, closely coupled, closed-cycle feeding system in a weightless environment.

No one knows what would be revealed by a study of any substantial portion of the 40,000 kinds of algae which exist. There may be one in this group whose aquatic temperament is ideally suited to the slavish service required in the unremitting production of food for the Space man. The possibility also exists of finding a species better suited for use as human food than those presently known.

Even less is known of the somewhat higher plants such as the ferns, lichens, and the like which, if they could be grown rapidly enough, would probably make for a drastic reduction in the water requirements of a closed-cycle system.

It is conceivable that the interposition of animals capable of using the algae as food might serve to provide increased acceptability in the Space diet. The algae, daphnia, small fish diet sequence has been suggested as a simple possibility. Virtually nothing of a quantitative nature is known about this set of occurrences; and, with the exception of a pitifully small number of misguided college students who have swallowed whole goldfish, nothing at all is known of the acceptability of the many, small-size, completely edible fish. Also, nothing very useful is known about their waste products, which would be cycled into the system were they to be an integral part of it.

Instead of a concentration of 50 percent of algae as supposed in our ideal bio-converter, present possibilities are of the order of one to a few percent. This is in part due to the limited availability of carbon dioxide and light but is as well dependent on ready access to nutrients. It would seem that the algae would grow at unheard of rates and to very high densities if these difficulties could be overcome by the intimate mixing of the culture with carbon dioxide, light, and nutrients. So far, the success of this conjecture has not been demonstrated.

For one thing, metabolic water would accumulate in the system along with cellulose, methane, carbon monoxide, and polymerized or insoluble substances unless steps were taken to keep each one under control. Theoretically, at least, all of these substances could be kept in the system by methods similar to those found in nature, the chief differences being in the size and the timing of the operations.

Electrolytic breakdown of extra-metabolic water would produce easily usable oxygen and together with it, the dilemma of large quantities of hydrogen whose destination in the cycle is still in question.

The use of a chemical analog of photosynthesis would have real advantage only if it were self perpetuating. It might avoid all of the vagaries of mutation and might even simplify to some extent the nutrient requirements of the system. What such a change would do for the Spaceman's personal diet is difficult to guess. At present there are few if any completely synthetic foods and still fewer savory enough to compete with any success against naturally occurring foods.

The body of scientists now working directly on Space feeding and nutrition is working effectively at a rate only attained by high motivation. But this motivation suffices, and their efforts will ultimately provide at least a partially closed Space feeding system by the time it is critically needed and, eventually, an ideal one for the long voyages of man into the remoter reaches of Outer Space.

primitive fear **(cont. from p. 18)**

uncertainty of the environment into specific problems. Roughly between six and four millennia ago, human rituals began to focus on seas, mountains and the sub-surface Earth. As in earlier extensions of awareness, specific events which threatened survival probably gave the necessary stimulus.

Concern with the seas in the Near East can be ascribed to an identifiable cause. About 4000 B.C. water from the Persian Gulf appears to have welled up over the Mesopotamian valley of the Tigris and Euphrates. It left Ur under 10 feet of mud and had a similar effect over an area 400 miles long and 100 miles wide. Since both the hero of the Epic of Gilgamesh and Noah were residents of the volley, the Epic and Biblical tales of survival have been attributed to this event.

Some of the traditions of a great flood from Greece, Lithuania, India, China, Australia, Polynesia and the Americas are of a similar age. The crustal, atmospheric or other causes of these catastrophic floods are unknown today, and certainly were not understood then. Human awareness of the larger threat to life may account for the worship of a sea-god, which in some places became preeminent at that time.

During the same period, our forebears were concerned with mountains and portrayed the fiery interior below Earth's surface. In the past, as at present, many volcanoes erupted and destroyed life. Such events may explain why volcanic mountains have been objects of fear and propitiation. All mountains may have come to seem unpredictable and therefore sacred—the Himalayas, Mount Sinai and Mount Olympus among others.

Crustal disturbances have also occurred, probably more than once, at the series of chasms and depressions which have been grouped under the name of the African rift. These extend through East Africa, the Red Sea, the Gulf of Aqaba, the plain of Sodom and Gomorrah, the Dead Sea, the Sea of Galilee, the River Jordan and into Syria. Evidence of eruptions of lava and frequent earthquakes have been noted along this line. It is believed that Sodom and Gomorrah were destroyed in about 1900 B.C. in an area now under water at the southern section of the Dead Sea. The destruction resulted from a great earthquake, which was probably accompanied by issue of natural gas, explosions and conflagration. Outpourings of lava from sections of the rift, as well as from volcanoes, may account for the fear of a burning hell below.

Great as was the concern with terrestrial forces, the celestial concern soon superseded it. Around the globe, communities began to worship a god high in the heavens. Earlier deities were relegated to subsidiary positions. Today, the Aborigines in Australia and Fuegians in South America resemble more advanced civilizations in their search for ways to secure the favor of a sky-god.

By the second millennium B.C. the vast idea that our world will end had begun to spread. In vivid detail, our ancestors portrayed a fiery consummation of Earth.

Many communities expanded their fertility rituals to include the larger environment. By sympathetic magic and extreme sacrifices, they sought to promote cosmic order. Among some peoples, altar offerings to heavenly deities included men, women and children. Others identified their priest-kings with the Sun. Through earnest service to the king, they hoped to ensure a world without end.

Some personified the sacred seven bodies with movements differing visibly from the stellar background. They sacrificed to the Sun, Moon, Mars, Mercury, Jupiter, Venus and Saturn.

Others sought satisfaction in the philosophical denial of life itself, and an effort to achieve mystical union with the cosmos.

Some envisaged a future life on other worlds in the heavens.

In this period, too, birth and after-life rituals became much more intense. Maternity, nativity and the generative organs were celebrated in varied ways. Beginning shortly after 3000 B.C. preparation of megalithic tombs for the after-life became a central activity for many peoples. By these means, men may have sought to defy the greater challenges to survival which they recognized in the larger environment.

The orientation and intensity of these rites suggest that something attracted our forebears' keenest attention to the cosmic environment. Each previous focus of ritual had a practical basis—from the large to the small game, rain, rivers, fertility, male cattle, seas, mountains, Earth's molten interior, and others. While the responses of prescientific peoples were necessarily symbolic, they all constituted attempts to cope with problems of survival. Religious practices directed toward the heavens hove likewise been symbolic; but it is reasonable to suppose that they also originated in vital concerns.

The source of concern, however, is difficult to establish. Judging only from the words of our ancestors, celestial disturbances occurred sufficiently close to affect Earth. Sacred, epic and historical documents from many ancient civilizations tell of such events.

Many explanations for these accounts have been offered. Theories range from solar eclipses, comets, polar toppling, or local catastrophes to Velikovsky's popular interpretation (*World in Collision*, Doubleday, 1950). The correct explanation has yet to be agreed upon.

In the present state of science, celestial events of the past cannot be as readily identified as can geological ones. One of the few modern clues is the dwindling of comets in the Solar system. These bodies were more common in ancient times than they are now. By measuring the present rate of decline in cometary luminosity, Russian astronomer S. K. Vsekhsviatsky has developed the theory that they originated a few thousand years ago. An event within the Solar System, which started the comets, could have had effects on Earth; or it could have appeared to threaten to do so.

Whatever the causes, an orientation toward the sky did develop in ancient times. Men devised a variety of ways to cope with cosmic uncertainties. Their beliefs have helped to form the civilizations current today. Peoples on Earth still carry on a wide variety of rites directed toward the heavens. Approaches to the cosmos, expressed in some of the religions of the period of written history, are the subject of the next article.

space and the law **(cont. from p. 20)**

Below these zones, states would exercise complete sovereignty. Unfortunately, the practicability of such a system is doubtful. The difficulties encountered in resolving conflicts over the extent of territorial waters still loom too large to convince us that territorial Space would be the ideal solution.

Should the status of Space be agreed upon soon, can we then proceed to develop a comprehensive legal code to govern it? This question has to be answered with due regard to the realities of international law and its sources.

Essentially, international law consists of principles established by time-tested customs or by treaties. Law based upon custom requires, by its very nature, lengthy periods of time to evolve and crystallize. The other source of international law, the treaty, is by far the more expedient one in terms of time, depending upon the ability of states to arrive at a common formula. Space, as a new thing in international law, may call for either way of originating applicable rules. The choice of source will largely rest upon the urgency for creating a system of Space law. Should the future dictate a pragmatic legal approach to Space whereby specific problems would be dealt with individually, then we may look forward to a slow and often painful emergence of Space law. It goes without saying that legal remedies developed in this way may come at times too late to be profitable in a dispute in Space and with possible disastrous consequences to the world as a whole.

On the other hand, while law is sometimes issued in anticipation of situations that might arise, rarely have lawmakers been in favor of bringing forth laws to meet unforeseeable complications. They have preferred to tread on familiar and tested grounds rather than stand the risk of providing an inadequate and impractical system of law in a new area of human venture. Legislation based on speculative contemplation of legal problems may often have more harmful consequences than a gap in the law.

Hence, the evolution of a Space code will undoubtedly have to wait until such time as the nature of Space and man's role in it are thoroughly explored and ascertained. So long as we are unable to foresee the full legal implications involved in human activity in Space, it would indeed be premature and presumptuous to devise rules and regulations purporting to constitute a Space code. It is more likely that concurrently with scientific progress in Space, law providing us with partial solutions will come into existence. Dr. E. Pepin, director of the Institute of International Air Law, commenting on the role of lawyers in the age of Space, put the matter in its proper perspective saying: "I was and still am of the opinion that they (the lawyers) should not impair the scientific progress by discussing abstract legal principles; but they should try to establish, if necessary, new principles which may facilitate the task of scientists."

Our venture into Space will eventually call for the creation of an appropriate international agency with adequate machinery to regulate, through legislation, our activities in this new area. If ever freedom of Space is to be fully realized without resulting chaos, we will have to make a centralized effort to coordinate the development of Space law. Though it is too early to attempt the formulation of a Space code, we may nevertheless establish the framework of broader principles discussed above. We may already equip ourselves with the necessary machinery to carry out the basic research preceding a statement of Space law. When Space rules do come into existence, they will have to be periodically revised so as to conform with constant technological developments. A flexible method for making changes in Space legislation will have to be adopted. The experience gained by the International Civil Aviation Organization in regulating airspace can certainly be put into use also for Space. As in the case of this organization, an international Space convention might establish a Space agency and entrust it with the power to supplement and interpret the broad principles contained in the convention itself. The ICAO successfully employs such a technique and it has devised special codes for the use of civil aviation, entitled "Annexes" to the Chicago convention. These annexes are revised and replaced by the organization in conformity with shifting needs. The flexibility that such a system affords will prove to be especially valuable in the initial stages of Space exploration when science and experience will frequently change our concepts and practices.

These are, in brief, some of the legal problems which may arise in the coming Space age. Should we succeed in making Space the domain of mankind as a whole, we can look forward to unprecedented progress and fruitful cooperation between nations. We hope that man's folly on Earth will not be carried into the cosmos. Space is awaiting us, but surely it is not eager that we project into it our earthly skirmishes and endless conflicts.

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