James G. Gaume, M.D.

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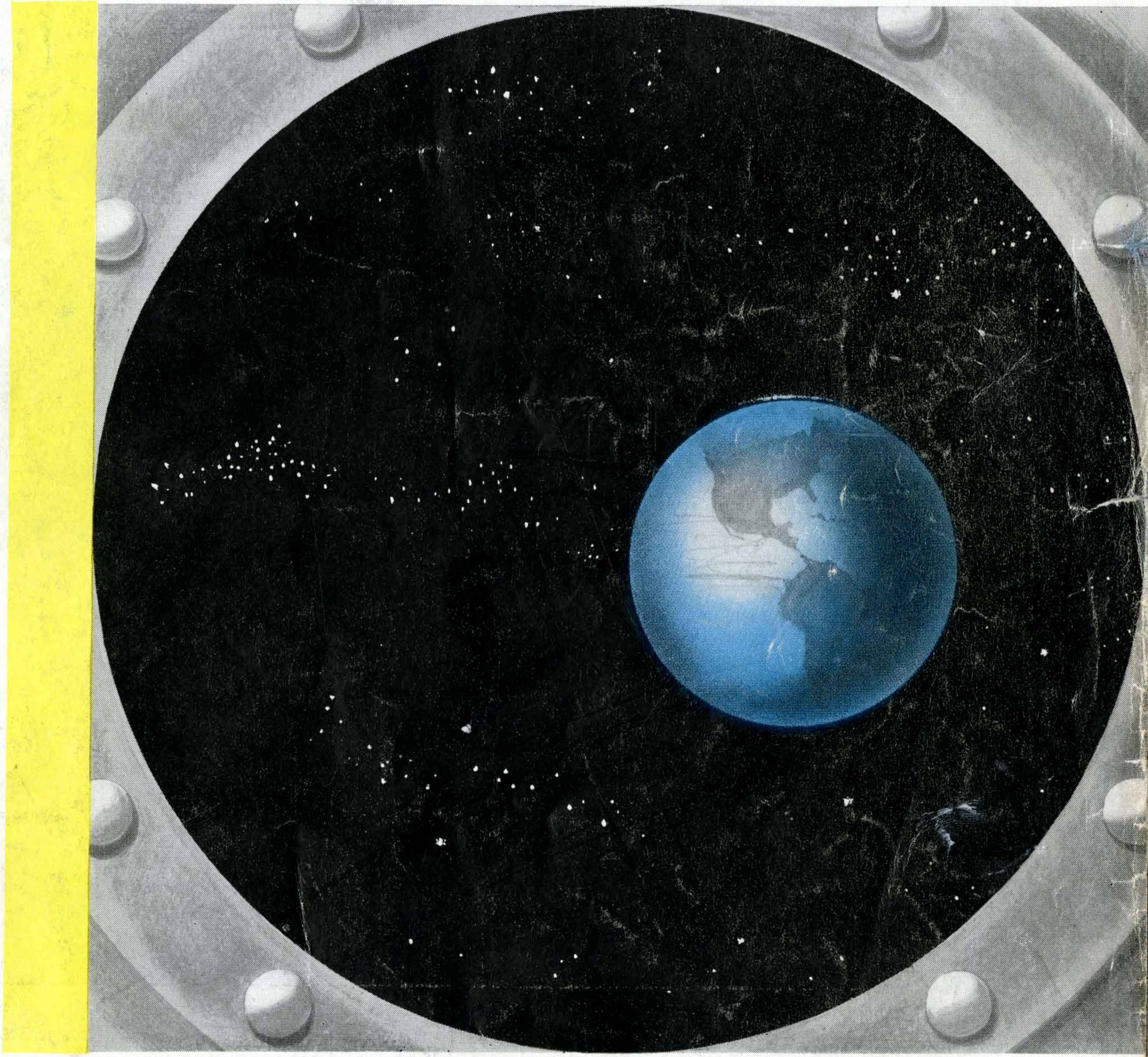
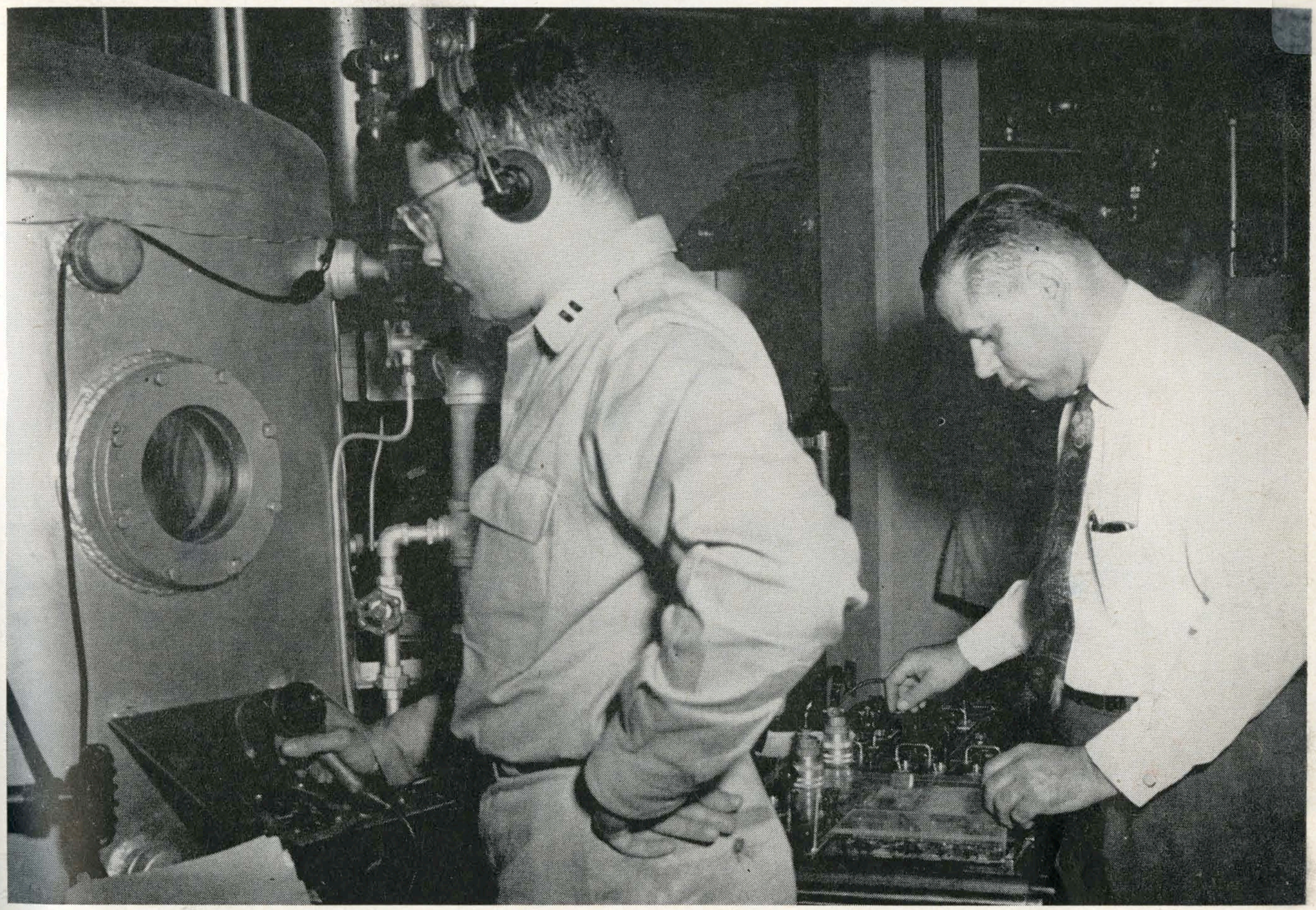


WINDOW INTO SPACE

Aero-Medicine's Peeping Toms



Capt. Emanuel Roth (left) and Dr. James Gaume monitor one of their experiments in the AF's space-cabin simulator.

Window Into Space

At one of our bases in Texas, aero-medics are exploring man's last frontier

By Ed Mack Miller
AND
Hugh Duncan

EVEN for April it was humid in the flat mesquite-lands and runty hills around San Antonio.

It was especially warm and uncomfortable for a young man at Randolph Air Force Base, for he was preparing to "leap" for the moon.

Wondering just a bit how this was all going to come out, the young man walked to the door of a bulky metal device that looked like a cross between a bathysphere and a science-fiction illustration. About the size of a furnace, the unit had a heavy, submarine-like door and thick glass portholes.

Dalton F. Smith, Jr., the young teen-age airman from New Orleans who had volunteered as "guinea pig" on this venture, took a deep breath, grinned at the technicians, and stepped inside. Scientists closed the bank-vault-like doors, sealed them, and the longest "endurance-in-space" test yet attempted was under way.

Inside, Airman Smith settled back for a twenty-four-hour trip which, it was calculated, could have taken him

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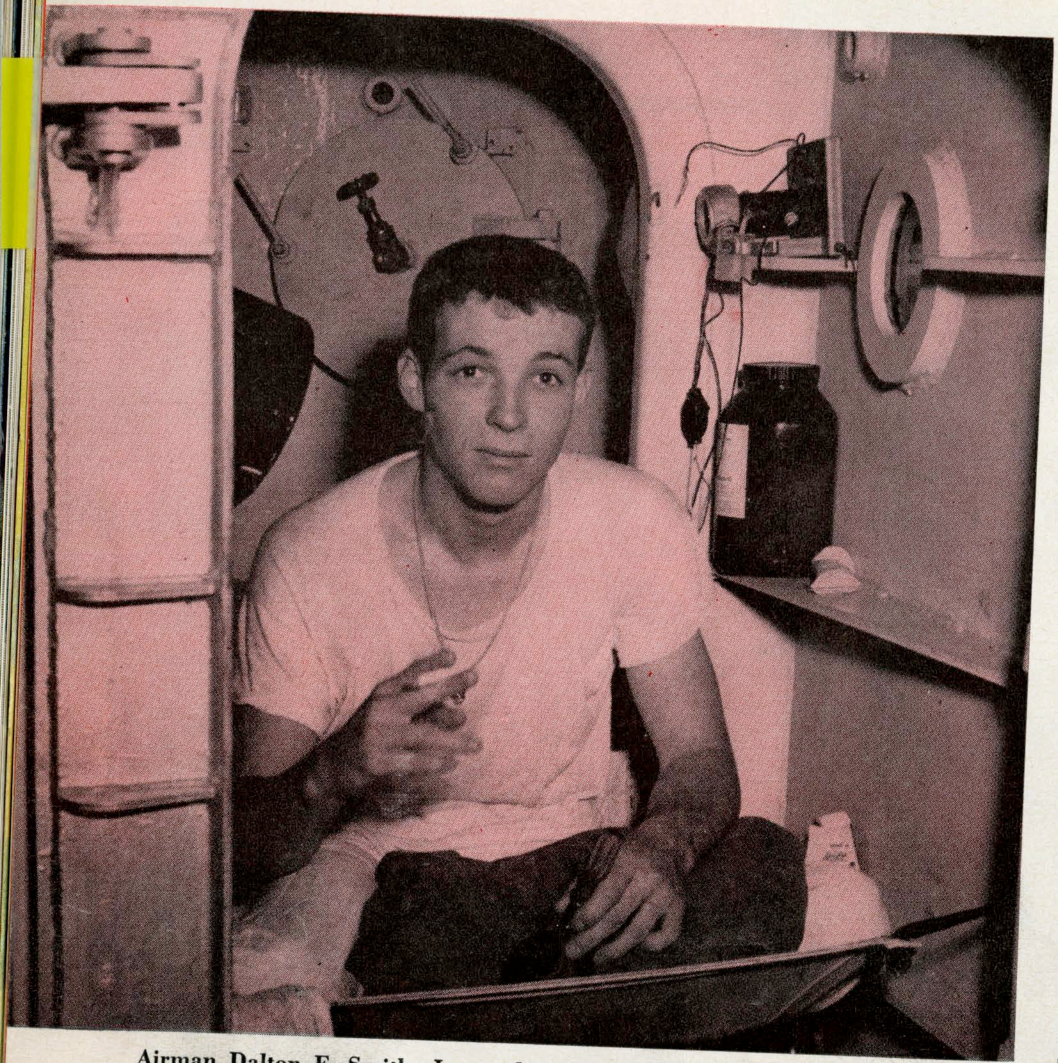


Airman Dalton F. Smith, Jr., settles back in his metal cocoon. His "trip" in the space-cabin simulator could have taken him "one-third the way to the moon."

was first organized by the air arm in 1918 "to investigate all conditions which affect the efficiency of military pilots, and to consider all matters pertaining to their selection and their physical and mental fitness."

The school was first known as the Central Medical Research Laboratory, but, after being transferred to Mitchel Field, Long Island, in 1921, its name was changed to the School of Aviation Medicine. In 1949 Maj. Gen. Harry G. Armstrong (later Surgeon General of the Air Force, then Commandant of the School of Aviation Medicine) established a Department of Space Medicine at the school, and placed at its head a distinguished aviation physiologist and physician, Dr. Hubertus Strughold. (General Armstrong was succeeded by Brig. Gen. Otis O. Benson, Jr., who after a three-year tour in Washington has returned as its head.)

Today the school is a branch of the Air University and works on its mission of aeromedical education, research, and specialized medical practice. Naturally, the most "photogenic" department of the school in recent years has been Dr. Strughold's space division, where a group of expatriate German scientists and American space medics have teamed up to keep the US ahead in researching ways of sending man's environment deep into the wilderness yonder.

WINDOW INTO SPACE

CONTINUED

"a third of the way to the moon." Actually, however, he would never leave the precincts of the School of Aviation Medicine, which occupies nearly fifty buildings at Randolph, for his "vehicle" was the space-cabin simulator, built to find out how far man's environment could be projected into space.

In his metal cocoon, Smith lived for a day exactly as though he were flying through space. Throughout the test, the simulator worked perfectly, supplying oxygen, removing waste products by chemical means, and recirculating body moisture to cool and condition the cabin—and at the same time purifying it for drinking water.

Smith's one thin line of communication with the outside world was an intercom system to physicians monitoring the experiment. The doctors carefully watched Smith through the glass windows and kept tabs on instruments recording the airman's pulse and respiration, as well as the temperature, humidity, and other cabin factors.

But even with these lifeguards hovering on the outside, danger crept through the sealed doors after some eighteen grueling hours of testing. At nine o'clock on the morning of April 1, 1956, while Smith was "drowsing in space," he accidentally disconnected the carbon-dioxide absorber. One of the doctors noticed that Smith's pulse and respiration had started to soar.

At first Airman Smith was too drowsy to understand what the doctors were trying to tell him: "Connect the CO_2 absorber!" Then he reached down slowly and sleepily reconnected the hose. His pulse and breathing were soon back to normal again as the absorber droned on, eliminating the dangerous toxic gases around the "guinea pig."

After it was all over, space-pioneer Smith allowed as how he wouldn't mind making a three-day trip to the moon—but first he wanted to get a good night's sleep.

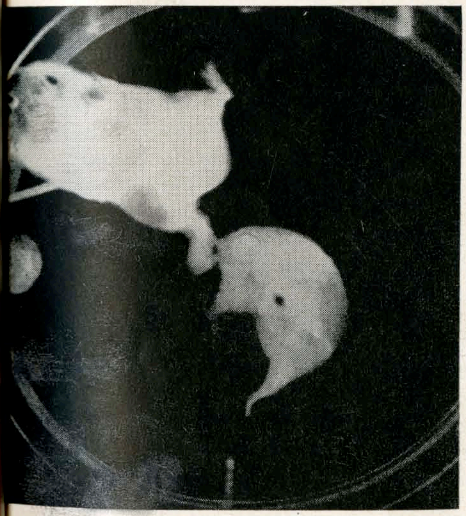
The School of Aviation Medicine

Dr. Hubertus Strughold, who heads the AF's Department of Space Medicine.

With tremendous powerplants pushing aircraft to the extremes of man's ability to ride along, the space medics have been hard pressed to keep up. And, in addition, there is always the wonder about the advances being made behind the Iron Curtain. It is known that the Russians have an institute of astrobiology, and it can be safely assumed that they, too, are pushing back the frontier of space.

There can be no doubt that there is now a "race for space," for the nation that can control the far heavens most surely will assume the position of the nation that controlled the seas in the ages before the airplane.

After World War II, when Communist Russia was stealing a good part of the cream of Germany's engineering brains, it was America's good fortune that German medical experts looked toward the US for freedom and encouragement in their experiments. Fifty-eight-year-old Dr. Strughold, one of those who came to this country after the war, is one of the pioneers of aviation medicine. As a professor with a Ph.D. from the University of Münster and an M.D. from the University of Würzburg, he taught physiology and aviation medicine in Germany, until he became a director of the Aeromedical Research Institute of Berlin. He is probably best known for two of his books, *Basic Principles of Aviation Medicine* and *The Green and Red Planet*, a study of the possibility of life on Mars. For his work on space medicine, Dr, Strughold was awarded the 1954 Hermann Oberth Medal of the German Rocket Society at a meeting in Innsbruck, in western Austria.



Mice floating in zero-gravity conditions during flight of an Aerobee III.

Dr. Strughold's chief assistants in the Space Medicine Department of the school include Dr. James G. Gaume and Capt. Emanuel M. Roth (*see biographies in companion story*). Also working with the group is Dr. Siegfried J. Gerathewohl, a German psychologist who studied at Dresden, Breslau, and Munich, became a major in the German army, an advisor to the German Aviation Research Institute, and a postwar member of the US. Army Air Force Aeromedical Center in Heidelberg.

Although, research-wise, Dr. Strughold and his staff have reached far out—farther than man has ever reached before—into the nebulous world of outer space, science has still gone only a figurative arm's length toward the unknown. There is still a tremendous amount of spade work to be done before man dares even inhabit an earth satellite, much less dream sanguine dreams of the moon. And this is because man is a hothouse flower, who must needs carry an envelope of his own atmosphere with him if he ventures outside of his earthly greenhouse. In outer space his two big problems will be finding a friendly environment and providing shielding from meteors and cosmic rays.

Toward the end of solving these problems, extensive tests have been made by both the Randolph people and other agencies using mice, turtles, and monkeys—and, in controlled hermetic environments, using man himself. Each advance brings with it new "bugs," so that the problem becomes to pick a priority for the channels of the maze that must be probed, for the temptations are great to wander into the highways and by-ways and miss the main objectives.

Some of the experiments now being hurdled include the design of pressure suits, oxygen equipment, and escape capsules, the probing of the mysterious features of weightlessness, heat radiation, the heavy primaries of cosmic bombardments, visual disturbances beyond our envelope of air, and the manifold problems of sustaining life in a tiny, speeding cell sunk deep in the hostile seas of the firmament.

To men of less courage and foresight the problems yet to be faced might seem unsurmountable, but the men of the space medicine unit take them calmly and in stride, untangling the ribbons of research one by one.

A token of their optimism that the skein of mystery will one day be unraveled was offered in a speech given recently in Rome by Dr. Gerathewohl, who told delegates to the Seventh International Astronautical Congress that, although many more tests had to be conducted before it could be said with certitude that men could strike

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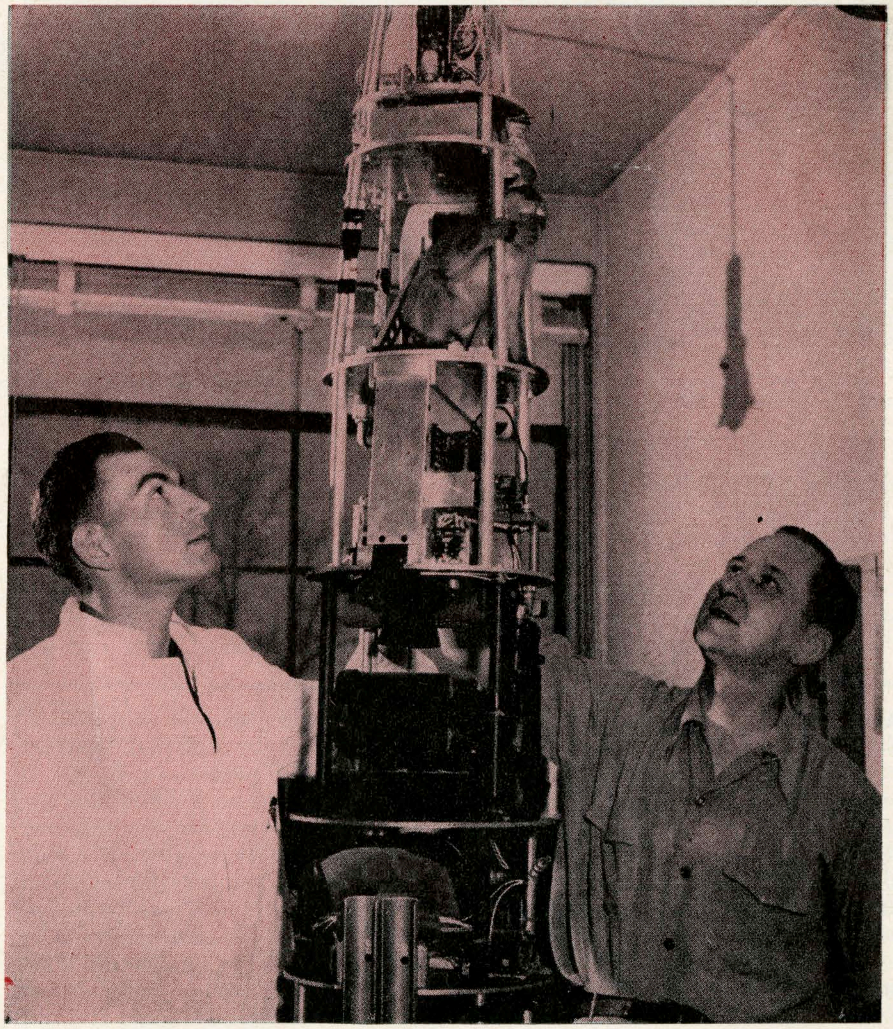
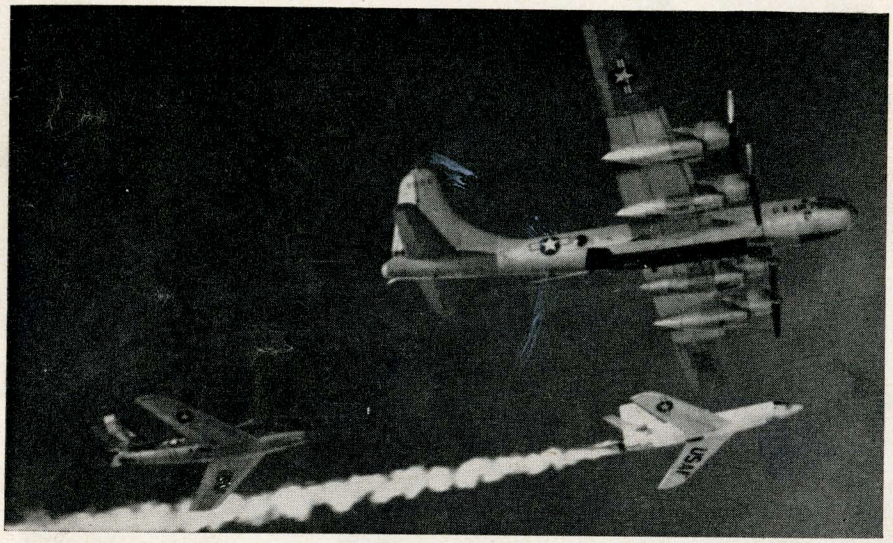


Monkey who rode a rocket forty miles up takes a dim view of WADC scientists.

out on their own in space, he did believe that the great problem of zero gravity would not stop selected crews from operating efficiently. Dr. Gerathewohl also added another problem to be overcome: space-sickness. Certain people, he said, will become nauseated up among the stars just the way some people get butterflies in a rowboat.

Detailing the personal experiences of some sixteen subjects who were exposed to short periods of weightlessness in high-speed dives in jet aircraft, the German scientist said at least one subject had become a fast convert of the weightless way of living. He quoted the pilot as saying: "Actually, I've never been so comfortable in all my life. I think if I had my choice of places to relax, a weightless condition would definitely be it."



Nibbling at the edge of space. Bell X-2 research plane (which crashed this fall) is dropped from its B-29 "mother" in start of an experimental flight.

Although the Department of Space Medicine offers, perhaps, the most inviting and most interesting work being done at the Texas center, space research is by no means the primary mission of the School of Aviation Medicine. The school's functions in educating flight surgeons and specialized medical practice—and most of the research done in other departments—are focused on the safety and efficiency of the present-day jet pilot.

Long-distance, hypersonic, space-equivalent flights are tomorrow's military necessity, and space medics must keep pace with speed engineers to keep the weakest link in the speed package—the human being—togged and masked, girdled and capsuled, so he can stay alive to perform his duties of guidance and intellection.

Not only do General Benson and his staff at the school search into the ever-unfolding problems, but it is also their two-pronged responsibility to train flight surgeons and medical officers. As time and space converge, the duties of all departments of the School of Aviation Medicine are brought closer together, for already the high-flying Century Series fighters and Fifty Series bombers are nibbling at altitudes above 60,000 feet, where the crews find that more than ninety percent of the earth's atmosphere beneath them.

Through the school, new and experienced officers can both be indoctrinated in the daily discoveries of aviation medicine. The Primary Course student is completely familiarized with the basic aeromedical sciences, all branches of clinical specialties, including dentistry, physiology, biophysics, internal medicine, space medicine, neuropsychiatry, and the many other facets of the trade of a doctor with wings. The primary student receives several hours of flight indoctrination, including time in conventional aircraft and in jet-flight simulators. He uses all types of flight equipment and becomes accustomed to low-pressure conditions. No physician is considered qualified to treat aeromedical reactions until he has completed this course, no matter how much professional training he may have previously received.

The school also offers an advanced course in aeromedicine for the specialist. In this curriculum the student is given extensive training in a variety of basic studies, plus actual clinical practice and nearly 400 hours of practical aircrew support training.

As for the space medicine research work, it is just that—research, for as operational planes go much above 60,000 feet (and the X-2, with Capt. Iven Kincheloe, Jr., at the controls, went to 126,000 feet in September) the sealed cabin becomes a necessity. And once the hermetic cabin becomes a reality, then space flight can become a reality and space medicine will change from a research art to a practical science.

But the modern-day mission of the School of Aviation Medicine is to "lay emphasis on the specialized medical care required to reduce the mortality rate from flying accidents and to protect the flyer's health and increase his efficiency."

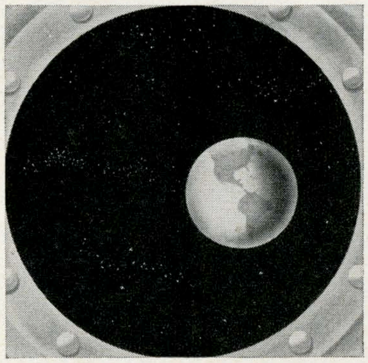
The job is one that becomes increasingly difficult with each stride science takes toward the stars.

But with men like Doctors Strughold, Gerathewohl, Gaume, and Roth, and courageous airmen like Dalton Smith working hard and long to give the US mastery of space, the results will not be long in coming, for these men are not just marking time in an interesting chapter from a science-fiction story.

As one observer at Randolph said: "The science is still here, but the fact has surpassed the fiction. Down here, if you listen carefully, you can hear the walls that bind man to his earth being tumbled down. These are awesome experiments for awesome times." —END

ABOUT THE AUTHORS

Ed Mack Miller is one of our most regular authors. His most recent offering was the article "Egg Heads in Hard Hats" in the October '56 issue. He lives "in a big house on a small lot" in Denver, from which he conducts his various enterprises, one of which is his work as a flight instructor for United Air Lines. A major, with more than 7,000 flying hours, he flies for the Colorado Air Guard. And as a free-lance writer, he employs one full-time and five part-time researchers, who this summer traveled 100,000 miles in nine countries. Ed's got a book forthcoming on the Strategic Air Command. Married, he's the father of three boys and three girls. His full-time researcher, the lad with whom he wrote this article and the following interview, is Hugh Duncan. Hugh, a native of Wyoming, splits his time between doing research for Ed and cracking the books at Regis College, Denver, where he's a student.



To Mars and Back HOW SOON?

(Working as a team, AIR FORCE *writers Ed Mack Miller and Hugh Duncan assembled the stories on the Space Medicine Department of the School of Aviation Medicine at Randolph Air Force Base, San Antonio, Tex. Following is an interview by recorder with Dr. James G. Gaume and Capt. Emanuel M. Roth, USAF [MC], on the practicality and problems of space flight.)*

* * *

Q. Within a short period of time, will we have manned rockets traveling from one continent to another?

Dr. Roth: The world's foremost authority on the medical aspects of rocket flight is Dr. Hubertus Strughold, the head of our department. He believes that we will.

Q. Approximately how soon?

Dr. Roth: Probably within the next five or ten years.

Q. What can you project as to space flight beyond these limitations? That is, when will space flight be interplanetary, or between here and the moon?

Dr. Gaume: That time is estimated to be within the next twenty years.

Q. Approximately how fast will a rocket have to travel to escape the earth's atmosphere and enter the realm of outer space?

Dr. Gaume: A rocket would have to travel what is called the "escape velocity," which is seven miles a second, or about 25,000 miles per hour.

Q. Would a manned satellite probably precede space flight?

Dr. Gaume: Yes, a manned satellite probably will, since one will place man sufficiently close to earth that he could return should something go wrong. The first satellites will contain no living things; the next ones will contain small animals, and then manned satellites will follow.

Q. Approximately how soon will you have manned satellites?

Dr. Roth: That's a difficult question. The unmanned spheres should go up in 1958, and animal satellites several years thereafter. I would say about five to ten years for human satellites. Closer to ten, most probably.

Q. Would a venture into outer space proceed from the satellite, or from the earth?

Dr. Roth: Most probably from the earth. That's my own opinion, though I know many experts feel that the take-off will be from a satellite. It's difficult enough to get a small satellite out and have it stay out there; it becomes another problem to provide more thrust from the satellite. Therefore, I would say that our first ventures into outer space will be direct, though at this point it's hard to say, since we don't know what kind of propulsive system we'll be using.

Q. What types are you considering?

Dr. Gaume: Several systems have been suggested, among them nuclear propulsion, ion propulsion, and photon propulsion.

Q. Would the vehicle be guided by its passengers, or would it be guided electronically from a satellite or from the earth?

Dr. Roth: Most of the guidance systems will be precomputed on an IBM-type device, and man will just be a monitor of this device. In other words, man would just monitor those devices which the machine cannot compensate by its intrinsic mechanism.

Q. What experiments have you conducted in your space-cabin simulator.

Dr. Gaume: In the space-cabin simulator we have kept a volunteer subject for a twenty-four-hour period; this was just a pilot study, and many of the conditions within the cabin were not ideal in relation to temperature and humidity control, odor control, and other factors. We have subsequently been working on these problems. However, as far as oxygen and toxic gases were concerned, he got along quite well for twenty-four hours. In future studies we shall use much more refined equipment, and we should be able to keep him going for days, or even weeks at a time.

Q. Will the cabin be pressurized?

Dr. Gaume: Yes, but not in the ordinary sense by compressing outside air. It will have its pressure sealed in.

Q. What is the difference between the "pressurized" cabin and the "sealed" cabin?

Dr. Gaume: The pressurized cabin is a cabin pressurized by the compression of the air outside the craft. The sealed cabin is pressurized from entirely within the craft; that is, the outside air is not used in pressurization of the sealed cabin.

Q. What is a hermetically sealed cabin?

Dr. Roth: That is a rather redundant term in that a hermetically sealed cabin is one that is completely sealed off from the outside. A tin can, for instance, would be a hermetically sealed cabin for a small organism.

Q. What atmospheric pressures will be within the ship?

Dr. Roth: The pressure in outer space is just about zero. The pressure within the cabin, however, will probably be about one-half an atmosphere, or seven and one-half pounds per square inch. Therefore, you will have a pressure differential of half an atmosphere between the interior and the outside, when you arrive in space. At 18,000 feet, they will be equal.

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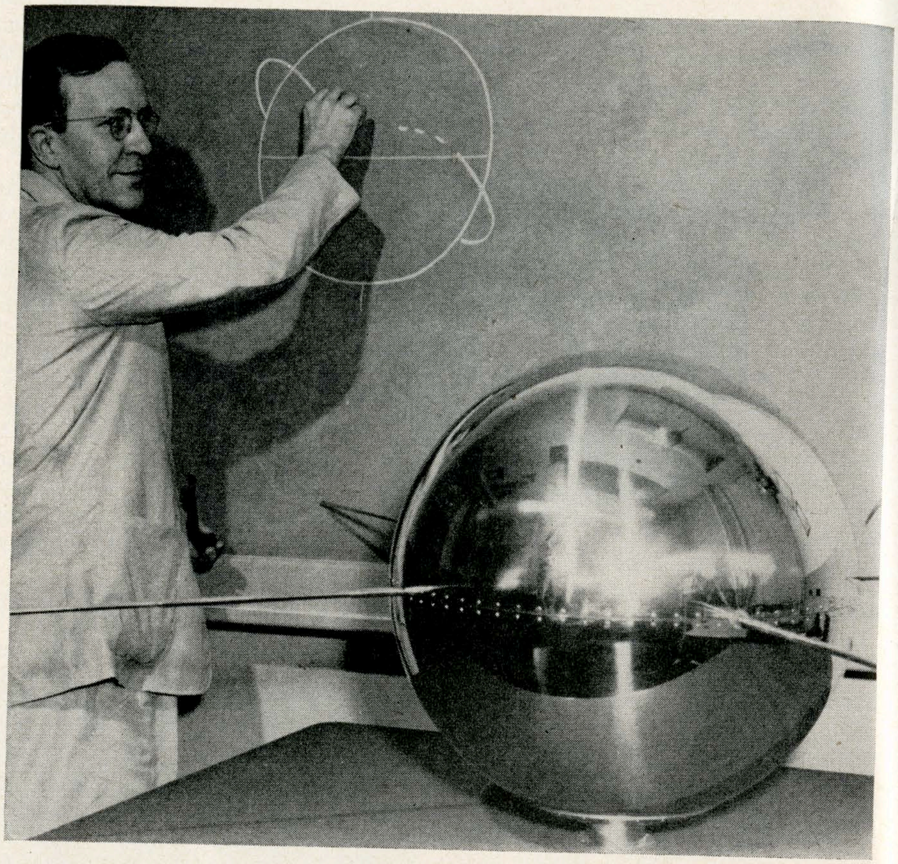


Dr. John P. Hagan, director of Project Vanguard, with full-scale model of the earth satellite. The twenty-inch globe will be launched by a three-stage rocket and will circle the earth at a speed of 18,000 mph.

TO MARS AND BACK—HOW SOON? CONTINUED

Q. What sort of an atmosphere will be needed within the cabin of a space ship?

Dr. Roth: Well, the atmosphere found within the cabin of a space ship would, ideally, be the same as that found on earth. However, engineering limitations impose certain restrictions on this. The lower the pressure within the cabin, the thinner the cabin walls, and therefore less weight in the rocket. The engineers would like to have us hold as small a pressure as possible within the cabin.

If we assume that we are restricted to a one-half atmosphere in the cabin, then to get a pressure of oxygen similar to that within our atmosphere we have to double the oxygen concentration, so that we would have a half an atmosphere pressure within the cabin with about forty-two percent oxygen concentration. We are presently studying factors of other gases involved in the cabin. There is a tendency for carbon dioxide to increase in concentration, and this would have to be kept below one and one-half percent. In oxygen production, we are studying the process of photosynthesis.

Q. What is the process of photosynthesis?

Dr. Roth: Photosynthesis is the process utilized by all green plants and some bacteria whereby these organisms are able to convert carbon dioxide into starches and sugars for their own use. It involves the utilization of sunlight, and in many cases oxygen is given off. Therefore, we are conducting algae experiments.

Q. What are the "algae experiments"?

Dr. Roth: The algae experiments now being conducted are for the purpose of determining how much oxygen is produced by the algae, and whether the algae, in absorbing carbon dioxide from man's respiration, can produce sufficient oxygen to balance the respiratory requirements of one man.

Q. This, then, will probably be used to furnish oxygen for the occupants of a space ship?

Dr. Roth: Yes, eventually.

Q. What changes will the occupant himself produce upon such an artificial atmosphere?

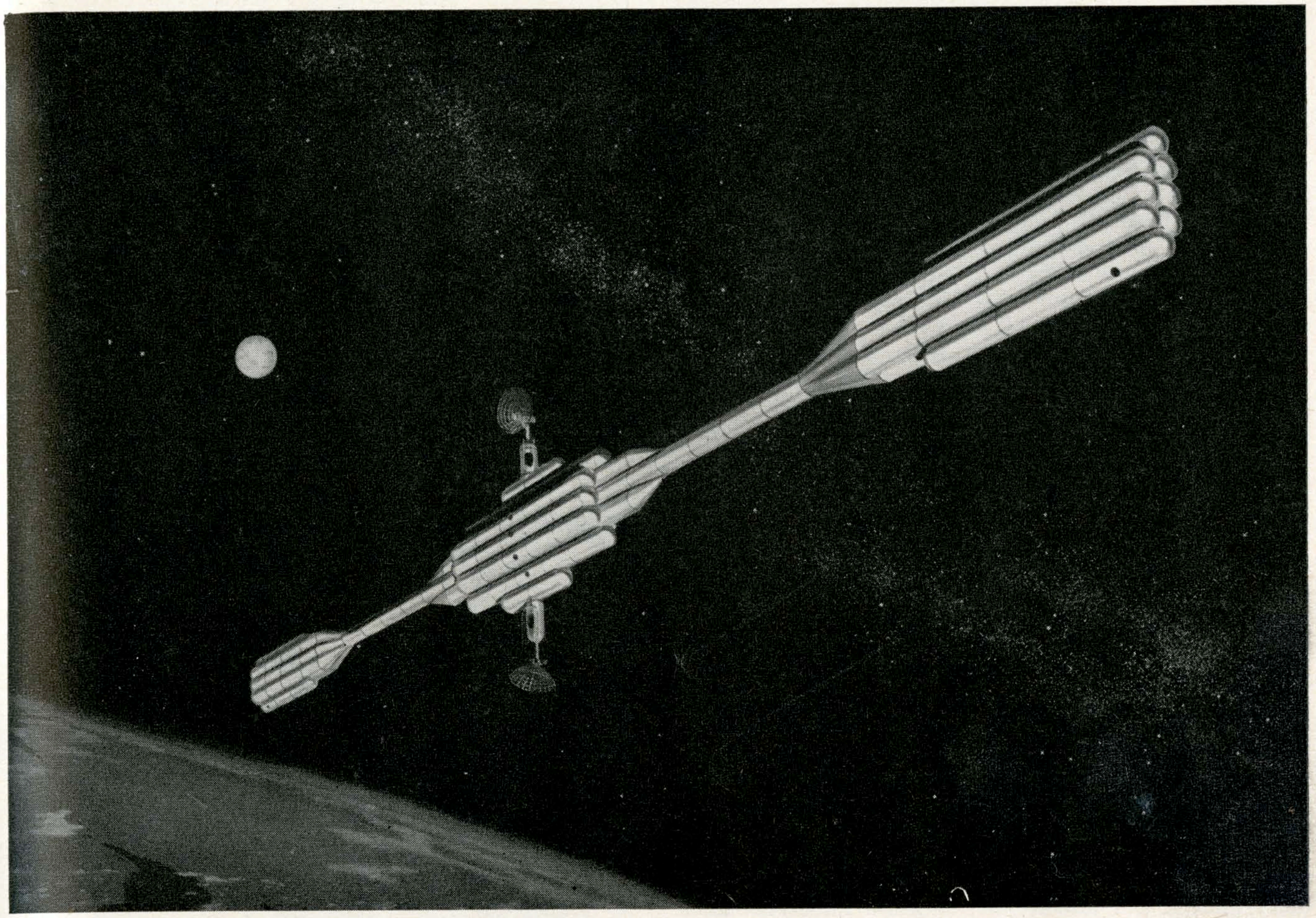
Dr. Roth: The human occupant will have a tendency to deplete the cabin of oxygen and fill it with carbon dioxide. Actually, the factor that would limit his survival within the cabin would be carbon dioxide. Man can tolerate a maximum of only five percent carbon dioxide, while his oxygen content can drop from twenty-one percent down to twelve percent before he begins getting marked symptoms of hypoxia. He will also produce other gases within the cabin, such as gases from the gastrointestinal tract, which must be taken care of before they increase to toxic proportions. However, the time for these gases to increase to toxic proportions is measured in terms of hundreds of days or years, instead of hours, as for carbon dioxide. A more important factor there is to see that unpleasant odors do not produce nausea.

Q. What would be the effect on the passenger of such a ship if, suddenly, the cabin lost its pressurization?

Dr. Gaume: You mean by collision with a meteor, or a similar reason?

Q. Yes.

Dr. Gaume: This would depend upon the size of the opening in the cabin, and the pressure differential across the cabin wall, and the volume of the cabin. With a large hole and high pressure, sudden decompression would be much more rapid, and the effect would be much greater and more rapid upon the passenger. With a small hole and lower differential, the effect would be more gradual, and there might be time to repair the opening within the cabin wall.



Artist's conception of a manned earth satellite that might act as a fueling station for space flights. It would be built up from third-stage fuel tanks of many automatic supply ships. Designer of this satellite is Krafft Ehricke, now of Convair's guided missile engineering staff, who was one of the designers of the German V-2 rocket. Mr. Ehricke's proposed satellite is 400 feet long and would weigh about 400,000 pounds. It would revolve slightly more than twice a minute, producing an artificial gravity one-third that of earth. Crew members would live at either end of the paddle-shaped vehicle, standing so their heads were toward the center of the satellite. Crewmen could go from one end to the other by ladders, climbing "up" toward the axis and "down" the opposite side of the spoke. At the center, they would be virtually weightless. Here the power supply would be housed and the supplies and equipment stored. Space ships arriving at the satellite would approach the axis of rotation, and the visiting space crewmen would wait for the satellite entrance to revolve to the proper position for boarding. Then they simply step from spaceship to satellite.

The effect on the passenger, of course, is directly proportional to the rate of decompression. In case of sudden decompression to zero pressure, the loss of oxygen pressure would give the individual about fifteen seconds of useful consciousness; the loss of the pressure within the cabin would cause the so-called boiling of the water vapor in the body, and this would give him a useful consciousness of about five seconds. The possibility of collision with a meteor of sufficient size to penetrate the cabin wall is remote, however, and Dr. Fred L. Whipple of Harvard University has suggested a "meteor bumper" as protection from these larger meteors.

Q. What is this "meteor bumper"?

Dr. Gaume: This meteor bumper is a shell around the craft, probably composed of a metal such as aluminum. The meteor would strike this, instead of the inner hull itself, and there would be a mutual destruction of the meteor and the point at which the meteor strikes the shell.

Q. Are there other elements of the atmosphere which could be harmful to the human upon exposure?

Dr. Roth: Well, the structure of the atmosphere approaches space from a level of about 52,000 feet on up. At 52,000 feet the oxygen is under so little pressure that air cannot enter the body from the lungs, and so man has reached an oxygen limit at this altitude. He can go higher than this, but will have only a fifteen-second survival time so far as his oxygen is concerned. At 63,000 feet you encounter an area where the fluid of the body begins entering the vapor phase, and will boil at body temperature. Therefore, in this general region, you have a limit so far as pressure goes. At an altitude of 70,000 to 80,000 feet the air becomes so rarified that it is not feasible to pressurize it; therefore, we must turn to a sealed cabin. Also, at the area from 60,000 to 80,000 feet, you encounter an area which is highly enriched with ozone, a toxic product of ultraviolet light striking oxygen molecules within the atmosphere.

This ozone has been studied by the Department of Physiology here at Randolph, and the Armour Research Foundation of the University of Illinois Institute of Technology. It is found to be a rather toxic gas, much more toxic than hydrogen cyanide. This is another reason why we would not want to take the air from this region and pressurize it within the cabin. This layer gradually fades out at around 120,000 feet, and the ozone concentration becomes somewhat negligible as far as the human is concerned. At around 75,000 feet we begin losing the blanketing effect of the atmosphere against cosmic radiation. Above this, cosmic radiation occurs in its primary form; below this altitude, it is secondary radiation that we tend to get.

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As we go higher, the air becomes more rarified, and so we have less and less of the ultraviolet light being absorbed. The ionosphere is the region in which the short-wave ultraviolet radiation is filtered out from the lower atmosphere.

When we get to the region around forty to sixty miles, we reach a point where most of our meteors are dissolved due to friction heat. We are protected by this little blanket of air; above this, we run into the full blast of the meteors. At around eighty miles, we reach the point where the molecules are far enough apart so that sound cannot be transmitted; first, the higher frequencies of sound disappear, and then the lower frequencies disappear.

At around 100 miles, one no longer has sound propagation, and all communication must be through electronics equipment. When we reach 120 miles, we are touching the friction limit of the atmosphere; above this point, friction is almost negligible. A body set in motion here can continue in motion for rather prolonged periods of time.

Although friction decreases gradually from here, the 120-mile line is generally accepted as being the frictional border. At 120 miles, the air is so rarified that heat produced by friction has a hard time passing from the outside air into the craft by convection, and so you have a border of heat transfer. Also, at 120 miles, we reach the area where zero gravity becomes the normal condition in the space craft, since there is no longer any lift or air resistance.

Above 500 miles we are in the exosphere. This is the outer limit of our atmosphere, and is a rather nebulous region in which the molecules are actually traveling from the earth into space rather freely, and so we consider this the "fringe zone."

Q. What is this "zero gravity" that you spoke of?

Dr. Roth: Zero gravity is the complete absence of weight; that is, a body will no longer be affected by gravity. The gravitational pull of the earth will be neutralized by centrifugal pull arising from the motion of the craft.

Q. In relation to zero gravity, how will the occupants of a space ship move about?

Dr. Gaume: Some engineers feel that it might be necessary to build in gravity in a space ship or a satellite by rotation of the vehicle in space, producing a certain amount of centrifugal force that would give an effect of a certain amount of gravity with which a man could orient himself. As far as moving about is concerned, we have not yet been able to produce "zero gravity" long enough to answer that problem.

Q. Then you have been able to produce a relatively gravity-free state?

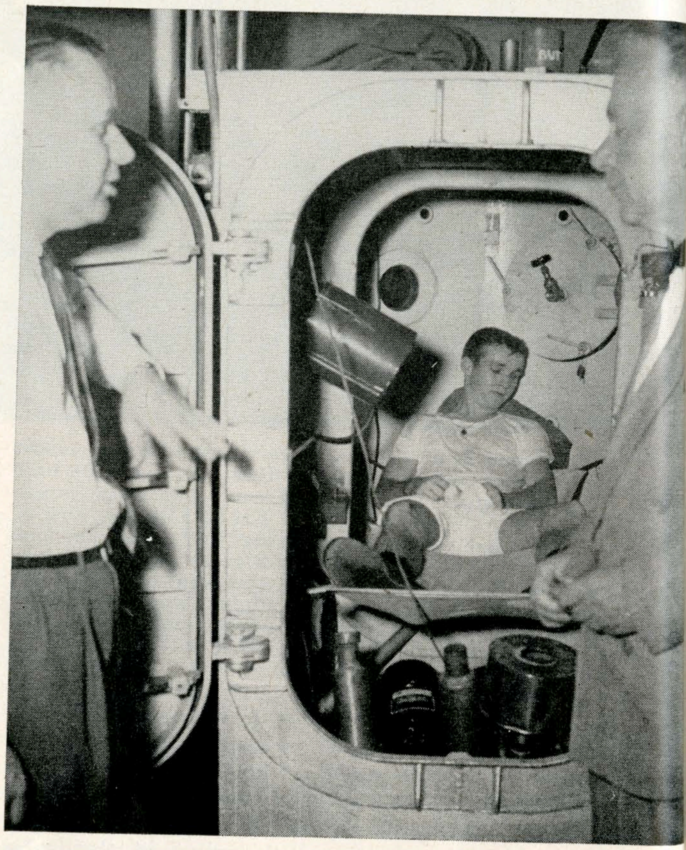
Dr. Gaume: Yes, we can produce a gravity-free state for a very short time in high-speed jet planes. In the F-94, which we have used in our experiments, a sub-gravity or gravity-free state can be attained for about forty or forty-five seconds. In rockets, a period of two and one-half to three minutes of gravity-free state can be attained. The eventual solution of the problems of the gravity-free state will have to wait until longer periods of time in the zero-gravity state can be attained.

Q. What effect, if any, will zero gravity have on digestion?

Dr. Gaume: From our studies in jet aircraft, it would appear that the person would not have too much trouble in either eating or drinking, although he would probably do better drinking through a glass tube. After he places the food in his mouth, however, he would have no trouble in swallowing or digesting the matter.

Q. Have you conducted an experiment in relation to the psychological reaction to zero gravity?

Dr. Roth: Yes, although all of our experiences have lasted no longer than twenty or thirty seconds. Even within this period, there are sideward and upward motions of the craft which prevent a pure zero gravity, so it's difficult to say. In the sub-gravity state, at least, we have noticed very little psychological difficulty. A certain number of people do get "motion-sick," and become disoriented from the zero gravity, but these are people who tend to become ill under any motion stress. We have found that about twenty-five percent of the people do get ill, and another twenty-five percent of the people



Drs. Gaume (left) and Strughold conduct experiment in "environmental and climactic conditions" in space cabin.

don't particularly like it. Fifty percent of the people in our experiments, however, have had no trouble at all, and even like the zero-gravity state.

Q. Over such a period of time as would be required for a venture into outer space, wouldn't the individual experience problems of confinement, even though he is not ordinarily affected by claustrophobia?

Dr. Roth: Well, that would depend largely upon how many people are in the crew and how much space they have to move around in. Submarine crews, for example, do not seem to suffer from confinement, even when exposed to cramped quarters for more than two or three months at a time. Therefore, it would really depend upon the physical condition of the actual cabin.

Q. In this cabin, what physical aids, such as padding and suits, will be used to aid the passenger in overcoming the effects of sudden acceleration upon take-off?

Dr. Roth: Actually, with present-day rocket data and

F-94s, like the one above, and T-33s have been used in experiments to produce a gravity-free state for short periods. Here F-94 pilot Maj. Herbert D. Stallings talks over problems of weightlessness with Dr. Siegfried J. Gerathewohl.

fuel capacities it looks as though the individual will have to be rotated into a reclining position; that is, perpendicular to the axis of the rocket ship. He would be in a modified beach-chair position, with his head at about heart or eye level. Then, when the gravity-free state is reached and after the motor has cut off, he can rotate back to a more conventional position, with respect to the long axis of the rocket.

Q. Will the human body, within the sealed cabin, raise the humidity and heat considerably due to respiration and perspiration?

Dr. Roth: Yes, the human body will greatly affect the atmosphere within the cabin.

Q. How will you solve this problem?

Dr. Roth: The problem can be solved with conventional air-conditioning equipment, the humidity being reduced by condensing the water on cooling coils, and the temperature being controlled either by a refrigeration device or a heating device, as required.

Q. Will the occupants be confined to this rotating chair and fed from, say, a tube?

Dr. Roth: There is no reason to expect that the individual will not be able to move about or eat normally.

Q. How will outer space affect the digestive system?

Dr. Gaume: It is doubtful if the gravity-free state of outer space will affect the digestive system of the body.

Q. Will the occupants of the craft be fed foods in capsule form?

Dr. Gaume: Suppose we just speak of food concentrates, rather than any specific type. Naturally, concentrates will permit a larger quantity of food to be carried on board, using up less total weight and volume. Whether they are consumed in concentrated form, or reconstituted by adding water and cooking, is not particularly important, because plenty of water can be made available, both for this purpose and for drinking.

Q. How can it be provided, without carrying a tremendous supply of water?

Dr. Gaume: Probably it will be water which will be recycled through air-conditioning systems, in that all the water lost by the body can be re-utilized and re-cycled within the cabin, and purified drinking water obtained thereby.

Q. How will waste materials of the body be disposed?

Dr. Gaume: We are conducting research in that right now. Waste materials contain certain essential elements and constituents that may be re-utilized in the same manner, with a different type of processing, as the water.

Q. After a space ship has passed the extremities of our atmosphere, will it still travel on power, or will it coast to a predesignated point and use power only in landing and take-off?

Dr. Gaume: Power will have to be used in altering course during flight, and in slowing down to orbital velocities in reaching the moon or another planet, and in landing and taking off from another planet. The distance of the flight will determine the amount of power used on take-off from earth. In a voyage from here to the moon, for instance, power will be used only for a short time, and then the rocket will coast the rest of the way.

Q. If a rocket were to fly to the moon, would the occupants land there, or would they assume somewhat of an orbit, go around the moon, and return?

Dr. Roth: Probably the first trips to the moon will be ones of circumnavigation, having an elliptical path; in other words, going around the moon, and returning to the earth, since it does require energy to slow down and land on the moon, and then more energy to take off. This requires fuel. If the first ships are fuel limited, it would be easier just to orbit around the moon and return to earth. But it depends upon our propulsion system.

Q. Assuming, then, that you could place a man on the moon, what problems would he encounter?

Dr. Roth: Well, the moon is a rather barren body almost entirely devoid of an atmosphere. That is why it is seen so clearly, since there is no atmospheric distortion. Since there is no atmosphere, meteors do not burn up before landing, and so the surface is probably peppered by meteorites of all sizes and shapes. Many of the craters seen on the moon may actually be the result of some of these meteorites plunging into the surface unimpeded by an atmosphere around the moon. Gases are non-existent, so man would have to supply all the gases for respiration.

In regard to gravity, the gravity of the moon is very much less than that of earth. In order to escape from the earth into space, man will have to reach a minimum velocity of seven miles per second. However, in order to leave the moon, a velocity of only one and one-half miles per second is required. The moon's gravity, therefore, is about one-seventh of that of the earth. Temperature-wise, the moon runs from about 250 degrees Fahrenheit in the heat of the day down to almost minus 300 degrees at night, and so there is great temperature variation during the daily cycle.

(Continued on following page)

Q. What are the human limitations in regard to heat and cold?

Dr. Roth: Well, in regard to heat tolerance, a man, clothed in regular summer dress, when suddenly exposed to a dry, hot air environment of, say, 400 degrees Fahrenheit, will be able to survive only for a period of about five minutes. If you reduce this temperature to, say, 212 degrees Fahrenheit, or the boiling point of water, he will have thirty minutes of survival time, though his functioning will be poor throughout the latter part of this period. As you change the humidity factor, you change the survival time. So far as cold is concerned, anesthesia today is often accompanied by a freezing of the patient to decrease his metabolic rate and blood flow requirements. Temperatures as low as seventy-five degrees Fahrenheit have been tolerated without difficulty. Once you get below seventy-five degrees, you begin getting irregularities of heart action, and this temperature becomes rather dangerous. In this case we are speaking of the body's own temperature, of course. Suitably clothed, a person can stand almost any degree of cold in the environment around him.

Q. How cold does it get in outer space?

Dr. Gaume: The temperature in outer space depends, actually, on the amount of absorption of solar radiation. The side nearest the sun of a body placed in outer space would be very, very hot, while the opposite side would be exceedingly cold, and there would be a temperature gradient between the two; but the temperature differences even on a very narrow plate will be quite remarkable. This is one of the problems which the Air Force's engineers have to solve; that is, the problems of solar heating of structural materials in rockets when they enter space.

Q. What other hazards will the space voyagers encounter?

Dr. Roth: Within the cabin there should be no apparent difficulty which could be attributed to the effects of space. Outside the cabin one encounters problems of meteors, cosmic radiation, heating effect, temperature effect, dehydration—actually, within a pressure suit in outer space, one would have problems which are very similar to those within the cabin, except that they are exaggerated by the fact that most of the equipment is of a portable, temporary type. Therefore, his danger in relation to the hazards is increased, and the chance of his being able to repair a defect within his suit is reduced.

Q. What will be the effects of ultraviolet and cosmic radiation upon the human who ventures into outer space?

Dr. Roth: Ultraviolet radiation offers no problem, since this radiation is easily blocked out by common glass or the metallic structure of the rocket craft. Cosmic radiation is an altogether different problem, as not enough is yet known about the effects of cosmic radiation of high concentration on the body. We have been attempting to study the effects of these problems through the use of experimental animals.

Q. Then you have sent animals into outer space?

Dr. Roth: Yes, mice and monkeys have been sent as high as 100 miles in rockets from White Sands, New Mexico.

Q. Have there been any changes, genetic or otherwise, caused by the exposure of these animals to the elements of space?

Dr. Roth: These changes are usually rather long term, and the animals have only been back from their trip for less than five years. They are presently living in retirement in the National Zoo in Washington, and are being carefully watched for any genetic changes, or any structural changes in their bodies or the bodies of their offspring.

Q. What planet, within the limits of present knowledge, would be best suited to sustain life as we know it here on earth?

Dr. Roth: Mars seems to be the best planet for sustaining life.

Q. What would some of the problems be on Mars?

Dr. Roth: Man would have to be protected against temperature changes on Mars. There is a long period during the day when temperatures are similar to those on the surface of the earth, but it gets extremely cold at night on the side of Mars away from the sun, and man would have to have some well-designed heating equipment to keep warm.

There appears to be some water on Mars. There are polar areas which probably represent ice. These polar areas shrink in size during various seasons, and it is possible that these vaporize into the atmosphere in the form of water vapor. I don't believe that anyone has seen anything resembling surface water on Mars. The so-called "canals" are rather nebulous in that one does not see water flowing in them, if, indeed, they exist at all. The only indication of water is in the polar areas.

The gravitation on Mars is less than that on earth. While it would take an escape velocity of seven miles per second to leave the surface of the earth, it would take only three miles per second to leave the surface of Mars. It depends, actually, on the ratio of the mass to the diameter of the planet. This is the factor that determines the gravitational pull on the planet, and, in turn, determines the escape velocity required.

Q. As a final question, could you project anything as to possible life, plant or animal, on other planets within our solar system?

Dr. Roth: Venus is rather densely covered with clouds, so it is almost impossible to find anything that would indicate life there. The structure of the atmosphere of Venus is rather nebulous, because it is distorted by these clouds, and we cannot penetrate these cloud layers to get any accurate assays as to what is up there. There are areas on Mars, however, which change color seasonally and resemble areas of vegetation on earth.

They are brown one season and a greenish color the next season. However, the green does not appear to have the same spectral qualities as the green seen in the plants on earth. This does not negate the possibility that there are other catalysts resembling chlorophyll and other pigments that give a pattern of green as seen in these areas.

As far as the other planets go, I don't think that there is enough available information to indicate that there is life on them. The conditions seem to be best on Mars when we think in terms of life on earth. Now, there might be other metabolic systems incorporated in other planets, and so you might be able to have what we consider living things without oxygen. But, as far as we know life on earth, Mars seems to be the planet which would best support it.—END

Dr. Gaume, born in Oklahoma in 1915, was graduated from Kansas State and took his M.D. from Creighton University in 1940. He entered the AF in 1942 and served as a flight surgeon in North Africa, Italy, and Indo-China. He returned to private practice after the war and in January 1956 joined the staff of the School of Aviation Medicine. Captain Roth was born in Boston in 1929, was graduated from the University of Massachusetts, and took his M.D. from Harvard. He entered the AF in 1955, and was in air evac before going to Randolph.