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EDITORS:

The following exclusive interview with Dr. Hubertus Strughold, foremost authority on how to make "space flight" safe and practical for human beings, appears in the current issue of "U.S. News & World Report," and is released to the press, radio and television at 7:00 P.M., EST, Monday, February 27, 1956 (Tuesday Morning Papers).

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"U.S. NEWS & WORLD REPORT"

Interview — **with DR. HUBERTUS STRUGHOLD**
Expert on Space Medicine

COAST TO COAST IN 25 MINUTES

Reprinted from "U.S. News & World Report"

AN INDEPENDENT WEEKLY NEWS MAGAZINE PUBLISHED AT WASHINGTON

Interview with DR. HUBERTUS STRUGHOLD
Expert on Space Medicine

COAST TO COAST IN 25 MINUTES

Here, from a leading Air Force scientist, is a preview of a revolutionary new kind of airliner—one that will fly passengers by rocket at speeds hitherto undreamed of.

It is the authoritative story of the first practical application of "space flight," to be used for travel from one spot on earth to any other—all in a matter of minutes.

You get a report on what is being done now to make it feasible for a "rocket liner" to carry passengers almost straight up, 100 miles or more, then glide soundlessly to earth thousands of miles away.

This first look at the next mode of air travel is given in an exclusive interview with the man assigned by the U. S. Air Force to make it safe for humans to fly at the extra-high altitudes needed for manned-rocket flight.

Q What is the next step in man's conquest of the air, Dr. Strughold?

A The next step in the conquest of the "air ocean" is the penetration by manned rockets of those regions of the atmosphere which represent a kind of transition zone between the atmosphere and space.

Q Do you mean by that that you would have rockets carrying passengers high above the earth, from one city to another?

A Yes; in the not-far-distant future.

Q How soon?

A I would say within the next five or 10 years.

Q Would that be something like traveling in an artillery shell high into the stratosphere and then gliding down to earth somewhere else?

A During a certain part of the course, yes. At first we have to do with a short period of propulsion, or acceleration, and, after the cutoff of the motors, the rocket liner will make an elliptic curve.

Q This would be a wholly new way of traveling through the air from, say, New York to San Francisco—

A Yes.

Q Would it be faster?

A Much faster. It would be perhaps only 25 minutes.

Q From one coast to the other?

A Yes. And during this elliptic course, the vehicle attains projectile status, as you just mentioned, and after this the liner glides down into the lower atmosphere, let's say at an altitude of around 25 miles, and glides to the point of destination.

Q Say a vehicle goes from New York to San Francisco; about how high would it travel at its highest point?

A It would reach an altitude of about 100 miles or more.

Q One hundred miles above the earth?

A Yes.

Q And that would be traveling at several times the speed of sound, would it?

A Yes.

Q About how fast would you guess it would reach?

A It would travel around 15 Mach.

Q That's 15 times the speed of sound?

A Yes; in the vicinity of 10,000 miles per hour. And during this elliptic or parabolic flight the weight of the passengers will be reduced to some extent or even removed.

Q So that it would be very much like traveling through space?

A Yes, during this phase. The atmosphere extends up to an altitude of about 600 miles; space reaches down to an altitude of about 10 miles. That means we have an area between 10 and 600 miles that has many but not all the characteristics of true space. It contains some air, but the particles are so few and so dispersed that we can consider this border zone of the atmosphere as equivalent to space.

Q Can you use a pressurized cabin?

A When we reach an altitude level of about 14 to 16 miles we can no longer travel in a conventional pressurized cabin as it is used in the airliners which fly from New York to San Francisco or from New York to Paris.

Q Why not?

A Because the air around the ship is too rarefied. We would need very bulky compressors; and, furthermore, if you would compress this very thin air to a suitable pressure level it would become very hot, intolerable for the occupants. For this reason we must resort to a new principle of the so-called hermetic or sealed cabin.

Q That means a completely sealed-up vehicle?

A Completely closed, yes.

Q You would manufacture your own atmosphere inside of that vehicle?

A Yes; we have, so to speak, our own artificial atmosphere, and—

Q Will that be very hard to do?

A No, that would be relatively simple. Basically, the prob-

By 1966, Passengers Will Fly at 10,000 Miles an Hour . . . 100 Miles Above the Earth . . . To Any Point in the World

Dr. Hubertus Strughold, interviewed by members of the Board of Editors of *U. S. News & World Report* at his headquarters near San Antonio, Tex., is the world's foremost authority on how to make "space flight" safe and practical for human beings.

Dr. Strughold, a noted German-born scientist, came to the U. S. soon after the end of World War II to continue his work. He became Chief of the Department of Space Medicine, U. S. Air Force School of Aviation Medicine, Randolph Air Force Base.

Now 57, Dr. Strughold studied both medicine and natural sciences in his native Germany, acquiring Ph.D. and M.D. degrees. Prior to World War II, he was director of the Aeromedical Research Institute in Berlin and became widely known for his pioneer research in the medical problems of space flight.

lem is to obtain and maintain a self-sustaining ecological system.

Q Ecological? What does that mean?

A "Eco" comes from the Greek word "oikos" that means "house," or the environment, and ecological space is a space which is adequate to house people or organisms.

Q In other words, adding oxygen and withdrawing carbon dioxide?

A Yes; and controlling the temperature and keeping the humidity within comfortable limits. That is what we understand in a self-sustaining, closed ecological system.

Q Would it get very hot inside the cabin at that altitude?

A That depends. Flying at such great speed, there is a heat problem that comes from friction of the craft with the atmosphere. That problem will be solved by the engineers. Another problem—a medical one—is the increase in temperature within the cabin from heat produced by the human body itself. On flights of such short duration as the ones we are speaking of, that will not give us any trouble.

Q Could you tell us something about the sensation that the passengers would feel in a rocket 100 miles above the earth?

A Yes. During the period of acceleration—that means during the first minute or so—they would have the feeling that they weighed twice as much as normal because they are under a higher force of gravitation than they are accustomed to on earth, and during the time the vehicle makes this elliptic or parabolic curve their weight will be much reduced, or even removed altogether, and they will have the sensation of being without weight.

Q Will they float through the cabin?

A No; they will have their belts just as in the conventional airliners.

Q Would loose objects be floating around? In other words, could they have lunch, say, during this process, during the trip?

A It would be better perhaps to wait for the lunch until after this flight.

Q Wait till they get there?

A Yes.

Q Will there be considerable turbulence in the plane during the flight?

A I do not think so. There is no weather at those great altitudes, and the flight should be much smoother than anything we experience in conventional aircraft.

Q Would there be any noise, or vibration, or anything like that?

A Not after the first few minutes, because, from then on, they will be gliding with the engines off.

Q Would the passengers hear the noise of the rocket engine?

A No. Even with its rockets firing it would not be heard because it leaves the sound behind, just as the V-2 bombs did during the war. Besides, above 80 miles the atmosphere is incapable of transmitting any sound.

Q Will the passengers be able to see outside?

A Sure.

Q Will they be able to see the earth below clearly?

A They will see below them a veil of whiteness of the earth.

Q Whiteness?

A Yes. They will for the first time get an impression of what the astronomers call a planet's "albedo."

Q What is that?

A Albedo. That comes from the Latin word "albus," white; albedo, whiteness. That is the reflected light from a planet.

Q What is up 100 miles above the earth? Is there any atmosphere at all?

A Yes. As I already told you the atmosphere reaches up to about 600 miles. However, this atmosphere has no useful effect on the human being or the aircraft. It is, so to speak, imperceptible; it is not any longer tangible.

(Continued on next page)

. . . "The probability of running into a meteor is remote"

Q The molecules are spread out far apart?

A Yes; yes. The air is too rarefied.

Q How about the problem of meteors? Wouldn't there be a danger of running into some, or having a crash in mid-space somewhere?

A According to the opinion of the astronomers, the probability of running into a meteor is remote.

Q Is there any way to—

A Even in a satellite; and especially this is true for such hypersonic space-equivalent flights, as I would like to call these flights we just mentioned.

Q Is there some way to guard against the possibility of an accident involving a meteor?

A Yes. We can use, as has been suggested, for instance, by Dr. Fred Whipple, astronomer at Harvard University, a "meteor bumper."

Q What would that consist of?

A It would consist of an outer layer of steel which surrounds the vehicle.

Q And that would be sufficient to protect the vehicle?

A It would absorb the impact of a meteor.

DANGER FROM COSMIC RAYS

Q It has also been suggested, in science fiction anyway, that there is a danger from cosmic rays if you get far enough away from the earth's atmosphere; you get direct cosmic rays. Is there any real danger there to the passengers in these vehicles?

A This problem is at the present time under very careful study. It is carried out mainly by Maj. David Simons at Holloman Air Force Base, N. M., with great skill in high balloons which fly up to about 100,000 feet. At the present time we cannot say with certainty if there are serious hazards involved, but I do not think for such short hypersonic space-equivalent flights that there is a danger for the passengers from cosmic rays.

Q Have any living things been sent up anywhere near that altitude?

A In rockets, mice.

Q Mice?

A And monkeys.

Q They have gone that high?

A Up to about 36 miles, which is practically the same as 100 miles from the standpoint of space equivalence.

Q And the mice survived with no injury?

A Yes. The monkeys, too.

Q Has anything been done to simulate the kind of cabin you would need to travel that high into the sky?

A Yes. We have, at the School of Aviation Medicine, an experimental sealed chamber and in this chamber we study, first, the change in the composition of the atmosphere produced by the presence of an occupant—to some extent we can calculate that—and, second, we try to develop devices which will automatically keep this chamber at physiological levels.

Q At physiological—

A At physiological or tolerable levels. That is the purpose of this cabin. We know what man can tolerate, we know the limits.

Q You have learned how to manufacture an artificial atmosphere within this cabin?

A Yes, and to maintain this atmosphere for a considerable length of time.

Q Now, has anyone stayed inside of this—

A Space-cabin simulator.

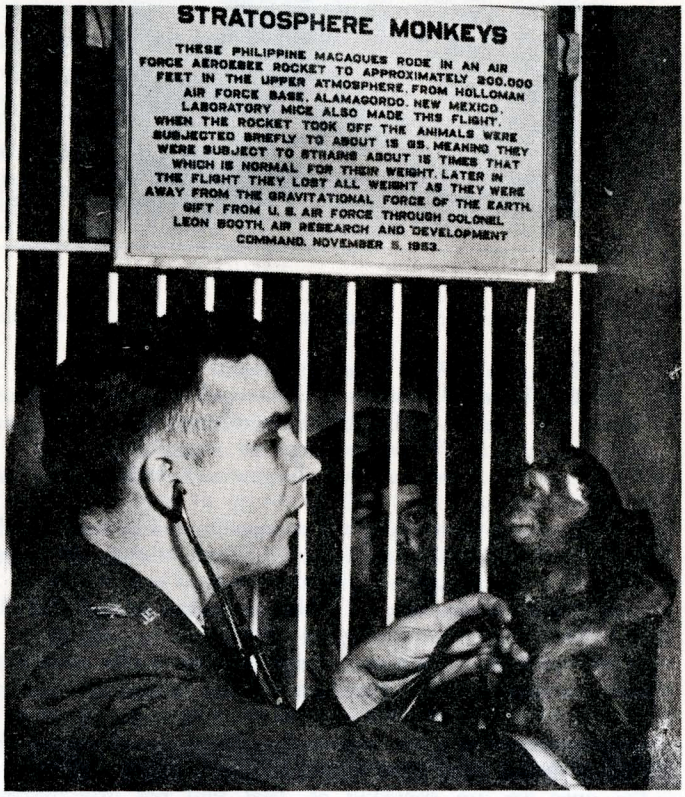
Q —space-cabin simulator for any length of time with an artificial atmosphere?

A We are just—studies have been made so far with regard to the kind of atmosphere we need, and these other studies—that is, the changes produced by the occupant—are now under way.

Q Has a man stayed inside one of these for several days?

A Not yet.

Q How about the rocket itself? Would it resemble, say, a V-2 rocket? Would it take off from a launcher and go straight up into the air?



—U.S. Air Force

FOR HIGH-ALTITUDE TESTS: MONKEYS
They have been taken up to heights of about 36 miles and survived without injury

A Similar—like that.

Q Even with passengers inside of it it would be a similar vehicle?

A Yes.

Q Would you have—would there be a pilot inside of it anyway to steer it?

A Sure. That is one of the most important differences between such a long-distance hypersonic space-equivalent craft and, let's say, a guided missile. A guided missile cannot change its mind if it is on its course, but with the—

Q This would be a humanly guided missile?

A So to speak, yes; a humanly guided missile.

. . . Rocket travel: "like gliding down a slope covered with ice"

Q Would it be a harder job for the pilot than it is now to operate jet craft, let's say? Would a pilot have more factors to consider on the instrument panel?

A I do not think so, because most of it will be automatic, except during the last few minutes before landing.

Q It would be more like piloting a glider, then, wouldn't it?

A Yes. The pilot would only make the approach to the field.

Q Well, how would it come down? Would it land on its tail, do you suppose?

A Now, we touch here an area which belongs more or less in the realm of the engineers. I believe some of them are thinking of a craft that would land vertically under rocket power, and others are talking about a normal glider landing. But that question isn't in my field. You see, the point is this: In space medicine, we anticipate this development or that development and we prepare the medical side for it, so that if the engineers come up with certain new devices we in the medical sector will know whether the human pilot is capable of using them.

Q You expect it and are anticipating this development, then? You expect it to come fairly soon?

A Yes, yes; because this is a logical development from the present-day long-distance atmospheric flights. One cannot prevent it; it will come.

Q How high has a human being flown right now, at this stage?

A In the rocket-powered X-1A, Maj. Arthur Murray flew above 90,000 feet almost two years ago.

Q How many miles is that? Around 17 or 18 miles?

A Yes; and this is practically space, because we have left behind at least three important atmospheric conditions: namely, first, the oxygen supply; then, second, the air pressure the body needs—we are physiologically, so to speak, in a vacuum—; and, third, at this altitude, we are in a zone where certain elements of the atmosphere itself are harmful, and so we must have a hermetically sealed cabin, at least if we fly for some time at this level.

HOW TO SURVIVE IN SPACE—

Q How did the pilot survive who went that high? He didn't have a hermetically sealed cabin, did he?

A If you dip, so to speak, into this area for a short time, only for a minute or so, then it is not necessary, but for a longer period of time—say for 10 minutes or more—you must have a sealed cabin.

Q I see. Now, he wore a special uniform of some kind, or equipment, did he not?

A He had to be protected either by a pressurized cabin or by a pressure suit; there is no question about that. It had to be one or the other, or both.

Q Will the passengers in this rocket liner have to wear special clothes or will they be able to go in the same clothes that they ordinarily wear?

A No; and that is another advantage in a sealed cabin. The passenger doesn't wear anything except his clothes, normal clothes.

Q Like a business suit?

A Yes. He should be as comfortable as possible.

Q How about the military use of such a thing? Have you given any thought to how it might be used militarily, though it's not in your field?

A I would rather make no comment in this respect.

Q Do you know what the Russians are doing in this regard?

A I have at the present time no knowledge about that.

Q Do they have a "department of space medicine" the way we have?

A I do not know. I know that they have an institute for astrobiology in which they study the conditions on other planets. I think we might assume that they are working in the field of space medicine.

Q Did the Russians get any German experts such as yourself after the last war?

A Not in the medical sector. They got a number of engineers, but no doctors.

Q How long have we been studying space medicine in the U. S.?

A Since 1949, when Maj. Gen. Harry G. Armstrong, who later became Surgeon General of the Air Force, established the Department of Space Medicine at the School of Aviation Medicine here at Randolph Field, where he was then commandant.

SOLVING THE HEAT PROBLEM—

Q We hear that one of the problems the guided missile people are facing with ICBM (intercontinental ballistics missile) is a difficulty of re-entering the earth's atmosphere after going up very high, that the vehicle will be going so fast that the friction will burn it up. Is there some hope that this problem has been solved, or is solvable?

A This again is a matter for the engineers, but it seems to me that this problem of heat from friction during high-speed flights on the re-entrance of the atmosphere will be solved.

Q Doesn't that also have an effect on the passengers, the danger of very, very high heat?

A It would have an effect, but I do not consider that as an important problem. The solution of this problem depends on the engineers, and I feel that they will solve it.

Q What would you think would be the psychological effect on a man traveling in a completely unfamiliar atmosphere like this and not weighing anything to speak of—looking down on the earth from 100 miles above it? Will his mental outlook be changed in any way?

A Yes. Now, the surrounding situation is this: It is dark outside; below you you see the reflected sunlight from the earth; in the sky you see the stars and, if you are not in the shadow of the earth, at the same time you see the sun. This is a very strange psychological situation, but it might be a fascinating one as well, so that the passengers would forget the dangers involved in such flights. The shortness of this flight, the time factor, also is very important. It might be that such short flights would bring no more psychological stresses than, let's say, a 15-hour flight across the Atlantic in present-day aircraft.

Q Would the passenger be more likely to feel more exhilarated or depressed by the combination of factors?

A I would say exhilarated. You must remember that, after the first few minutes, the flight is swift and smooth and effortless, like gliding down a long slope covered with ice.

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. . . "A sound man of good health" could withstand rocket trip

It might be that certain people would be more disturbed than others, just as it is with air sickness. Only a certain percentage of people are sensitive to motion sickness, and it might be the same with passengers on rocket flights, especially in the gravity-free state.

The orientation during this gravity-free state is purely optical, because we do not get information from the gravireceptors or the mechanoreceptors in our skin or here in the ear. Orientation is solely by the eye, and this is in complete contrast to the situation, let's say, in the deep sea. You know, there are deep-sea fish which have no eyes or only traces of eyes, because below 1,600 feet in the ocean it is completely dark, and they cannot see. They have nerves in their skin and they feel everything. Their orientation is given solely by these mechanoreceptors in the skin. Their photoreceptors in the eye are eliminated because it is dark and they

–U.S. Air Force

THE ROCKET-POWERED X-1A
In it, "Maj. Arthur Murray flew above 90,000 feet. This is practically space."

don't need them. In space, the reactions of our gravireceptors or mechanoreceptors—that means all the nerves which react to mechanical forces—they are eliminated and our orientation depends entirely on the eye. That is the difference.

Q Wouldn't the passenger have to be in pretty good physical shape to withstand the fast acceleration and then the fast deceleration of a trip like this?

A I would say not excessively. A sound man of good health could make such a trip.

Q Have people been subjected to acceleration and deceleration to the extent that would be involved here? I was thinking of Lieut. Col. John Paul Stapp; I believe—

A To acceleration, yes. Since, oh, more than 20 years, we have made studies of this kind and we know everything about that, about acceleration.

Now, the experiments of Colonel Stapp, which are unique, deal with sudden acceleration and deceleration, as in a crash. But here in such rocket flights as we might expect in the future the acceleration and especially the deceleration are extended over a longer period of time. They do not involve such high G [gravity] forces; only, at most, perhaps one, two or three G forces.

Q How long would the weightless state continue in, say, a flight from one side of the country to the other? Would it be a matter of a few minutes?

A Ten to 15 minutes, certainly, and longer in a phase of reduced gravity.

Q Ten to 15 minutes?

A Yes.

Q And it would feel as if you were going down very rapidly in an elevator for that length of time?

A No, no; it is only in the beginning of a descent in an elevator that you have any sensation of weightlessness. After that, your normal weight is re-established while you are going down. In a rocket craft, after it enters its elliptical curve, you will have a prolonged effect like the instant when an elevator starts to fall.

"FALL REACTION": A MYSTERY—

Q Will that be unpleasant?

A We do not know. You are speaking of the so-called "fall reaction" that people have at the beginning of a descent, when their support drops out from under them. We do not know if this fall reaction continues. I do not think so because some of our subjects experience that feeling only during the first few seconds of weightlessness, and then they become adjusted to the sensation.

Q Suppose these passengers wanted to travel farther than, say, one side of the country to the other? Is there any limit to the distance you could travel?

A No.

Q Not even around the world?

A No.

Q Is there a minimum limit?

A I think that is a good question. I think so; I think so.

Q How far would be the shortest distance?

A I would say less than the distance from New York to San Francisco would be impractical for rocket liners, just the same as I would not use a bicycle to ride around inside my own house. Of course there may be some ranch houses in Texas big enough to ride around in on a bicycle.

Q Would it be feasible to send passengers up into an orbit around the earth like the satellite vehicle which could go around the earth several times?

A I would say this: In that case I would not talk about passengers; they wouldn't be going anywhere but around and around. I would use the word researchers.

Q But people?

A Yes.

Q Well, it would be feasible, then, to send scientists up in a satellite vehicle?

A Yes; and this will come one day. In fact, we must have an orbital laboratory to study various conditions, such as the state of zero gravity, for a longer period of time. If we would like to know about its effects we must have somebody under zero gravity for several hours or several days. It might be that he will become adapted to it; it may be that he will have even more difficulty getting readapted to normal weight

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. . . In war, "rocket flight includes the element of surprise"

again, the way a sailor has trouble walking on land after a long voyage when he gets his "sea legs."

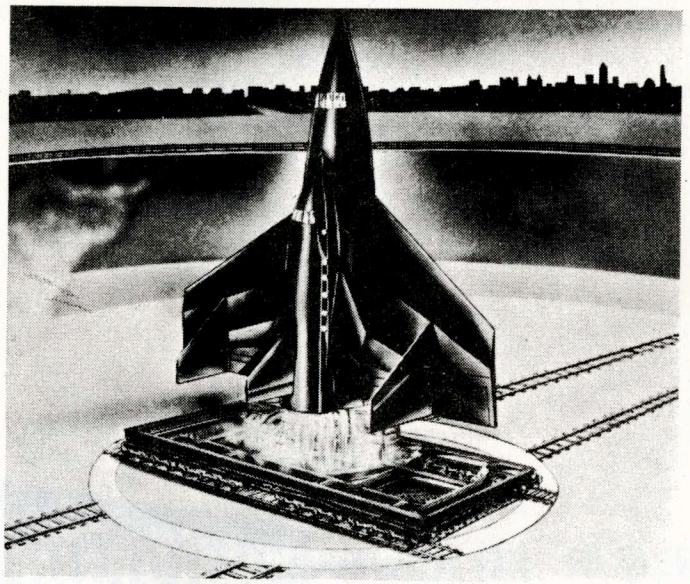
Such an orbital flight is full-fledged space flight in its simplest form; full-fledged because then we have all the conditions of space flight beyond the earth.

Q You learn how to do that and you can travel through space?

A The satellite is still within the atmosphere but outside the effective atmosphere; it is in what we call the pseudoatmosphere. It is the simplest form of space flight because there is no need to navigate, and so on; the satellite has its prescribed path. But the medical problems are the same that you would have on a trip to Mars or the moon.

Q How fast does a satellite travel?

A It travels about 17,500 miles per hour near the earth—less as you get farther away.



—Wide World

COMING: ROCKET AIRLINERS LIKE THIS?
"A humanly guided missile which will permit us to fly around half the earth in only 90 minutes"

Q The traveling from one part of the earth to another part of the earth would involve traveling at a speed considerably less than that?

A Yes.

Q It couldn't be that fast?

A No, because, if it were, you wouldn't come back down. The rocket airliner travels in the lower range of hypersonic flight. We call flying up to Mach 10 supersonic, and beyond Mach 10 hypersonic.

Q Mach 10—that's 10 times the speed of sound? About 7,500 miles an hour?

A Yes; below Mach 10 essentially aerodynamic factors are involved like shock waves and other similar factors, but as soon as we get beyond Mach 10 then the heat of the air in the boundary layers on the leading edges of the vehicle is very high; it goes up to 1,500 or 2,000 degrees. Under this condition chemical reactions take place in the molecules of the air; they get split, dissociated, or they become electric. So for this range of supersonic speed the engineers use the term hypersonic.

ATOMIC POWER FOR FLIGHTS—

Q How about atomic power? Is there any prospect that nuclear propulsion will replace chemical rockets?

A I would like to say this: If you follow the speeches given at the meetings of the International Astronautical Federation, you will learn they are working on the problem of nuclear propulsion, thermonuclear propulsion, ion propulsion, and even photon propulsion.

Q What is the last one?

A Photon propulsion? That means propulsion by particles of light.

Q Is there anything that passengers in a rocket liner would need besides oxygen and temperature control?

A Carbon dioxide removal.

Q It has to be removed?

A Yes.

Q Now, on a long trip you would need an awful lot of oxygen and have to remove an awful lot of carbon dioxide; is there any easy way to do that job?

A We know a method to catch two birds with one shot so to speak; that is, to produce oxygen and remove carbon dioxide at the same time. That is the process of photosynthesis by green plants.

Q Do you mean that you could take green plants along to do that job?

A Green plants. This process of photosynthesis started on the earth about 1.5 billion years ago, and it is primarily responsible for the fact that we have today a vast stock of oxygen in our atmosphere. It would take the vegetation on all the continents only about 30,000 years to produce the whole of the oxygen which we have today in our atmosphere, and if we include all the green plants that are in the oceans, the algae and seaweed and so on, it would take them only about 3,000 years to replace all the oxygen in the air.

At the same time these plants use the carbon dioxide that we breathe. If we used green plants in a manned satellite, we would be simulating this natural process in our artificial atmosphere.

Q What is the importance of the study of space medicine to the Air Force?

A Present-day rocket flights already involve space medical problems; that is the answer. For that reason we have to study these conditions, the space factors.

Long-distance hypersonic space-equivalent flights are inevitable; they are of great importance from the strategic point of view, because they permit us to fly around half of the earth in only 90 minutes. It is also important because rocket flight includes the element of surprise. It would make the United States, in the case of an emergency, independent of overseas bases.

Q Do you think, then, that the big problems of space medicine will soon be solved?

A By careful consideration of all the experimental space-medical data available, I would like to state that all the medical problems involved in space flight seem to be not insurmountable, unless there are still factors in space which are completely unknown to us—and that is very unlikely.