MAN'S FLIGHT INTO SPACE

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Since man first discovered the existence of other planets in the heavens, he has dreamed of travelling someday to these celestial bodies, to explore them and to satisfy his curiosity concerning the unknown. Because of his inability to transport himself physically to the Moon or the planets, man has devised a means of partially satisfying his curiosity by constructing telescopes through which he could explore them visually. The development of other instruments has enabled him to gather additional information about the sun and planets with regard to their composition. Through the centuries, he has improved these devices to ever greater perfection, and has discovered that those tiny points of light which he had called stars, are actually suns similiar to his own sun, but beyond his own solar system. These and other discoveries have stimulated man's dreams of actual space exploration. Today, space operations within our own solar system are rapidly becoming a reality. Indeed, it has been said that man is already flying in space.

If this be so, it immediately is obvious that a somewhat new definition of space is necessary. Space to the astronomer begins at the upper physical border of the atmosphere, or in the area of 600 miles from the Earth. To one dealing with the human factors of flight, space may be defined as that area which lies beyond the physiologically and physically effective portion of the atmosphere.

According to the latter definition, man is already flying in space. This statement can be clarified by presenting to you the concept of "Space Equivalence Within the Atmosphere" - a concept evolved by Dr. Hubertus Strughold Chief of the Department of Space Medicine, at the School of Aviation Medicine. He states that within the physical atmosphere, there occurs at ~~various~~ different levels the loss of all the various functions of the atmosphere, insofar as man and aerodynamic flight are concerned. The first function is lost

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at 52,000 feet or about ten miles, where the partial pressure of oxygen in the air is so low that it is prevented from entering the lungs, by the equal pressure of water vapor in the lungs. Even at slightly lower altitudes there is insufficient oxygen to sustain life, although a small amount can be absorbed through the lungs.

At 63,000 feet, the still lower barometric pressure is unable to keep body fluids in the liquid state, and the fluids vaporize as does boiling water, forming bubbles even at body temperature. These bubbles can snuff out human life in a few seconds. The new term -EBULLISM- has been suggested by Ward for this phenomenon, to replace the term "boiling of the blood" which connotes the application of heat.

These two, the oxygen and pressure borders, are physiological functional borders of the atmosphere. According to a physiological definition then, space begins at a level of 52,000 feet or about ten miles.

There are other physical functional borders which are encountered at various higher altitudes. Thus, as the barometric pressure decreases with ascent, the air density at 70-80,000 feet is so low that we are no longer able to use ambient air to pressurize the cabin of a craft. This may be called the pressurized cabin border. A sealed cabin must then be used above this level for the following reasons:

1. At 80,000 feet air density is only 1/30th the air density at sea level. To compress it to an acceptable level would require equipment that would be prohibitive in size and weight.

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2. If it were feasible to use ambient air, its compression would elevate the temperature of the cabin well beyond human tolerance, and would require a very large cooling system, again increasing the weight penalty.

3. At this same altitude the air has a high ozone content (6 ppm) produced by the action of ultra violet radiation upon atmospheric oxygen. This concentration is quite toxic to humans, and destructive to equipment, especially rubber and plastics, c̄ production of CO from the plastics. With compression adequate for physiological function, the total amount of ozone in the cabin air would be increased by factor of 10-15, and would necessitate some ~~device~~ means to destroy ozone.

4. In travel beyond the effective atmosphere, the ship will pass through the useable portion of the air with such speed that there would be very little time for outside air to be used for cabin pressurization. In less than two minutes the ship would be above 80,000 feet.

Out! There is one other important reason for a sealed cabin, although it has nothing to do with space operations. In flying through radioactive areas in any type of aircraft, even helicopters, a sealed cabin is the only one which will give complete protection to its occupants. All cabins which depend on ambient air for pressurization would be

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contaminated with radioactive dust, immediately upon flying into the area.

For these reasons one can readily see that a completely sealed cabin will be absolutely necessary in all forms of space operations. pause.

Under physical borders are included also the protective functions of the atmosphere. Factors which arise from beyond ~~the atmosphere,~~ but which are found within the atmosphere are solar radiation, meteorites, and cosmic radiation. At 120,000 feet primary cosmic rays begin to collide with the air molecules, causing them to explode into showers of secondary radiation particles. These in turn strike other molecules and the process is repeated, with an accompanying loss of energy of the particles with each successive collision. The atmosphere attenuates the energy of primary cosmic rays and thus protects us from their potentially harmful effects.

At 140,000 feet the ultraviolet of solar radiation begins to react with oxygen, producing ozone. The maximum ozone concentration is in the region of 70,000 feet and becomes less at lower ~~levels.~~ altitudes

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At about 75 miles (400,000 feet) meteors entering the atmosphere begin to heat up from friction with the air and most of them burn up completely before reaching the ground Without the air envelope, we would be under continual bombardment by meteors, as is the surface of the moon.

In the thinning atmosphere above 75 miles (400,000 feet) sound audible to the human ear will no longer be transmitted, because of the decrease of air density to a point below that required for sound transmission. Above this level, the [mean molecular] distance travelled by the air molecules between collisions becomes greater than the wave length of audible sound. The higher frequencies with shorter wave lengths will disappear first, followed by the lower frequencies. This results in the absolute silence of space.

The same thinning of the atmosphere eliminates its capacity to scatter visible light. The blue color of our sky is caused by the scattering of visible light by the air molecules. So, at 80-100 miles the sky is black, with the sun, the stars, and moon all visible at the same time.

The last physical functional border lies in the area of 120 miles. Above this point, a craft moving at any speed no longer obtains "support" from the air and there is no longer friction heat or its transfer to the interior of

(Aerodynamic + Aerothermodynamic borders.)

the vehicle. Above 120 miles solar infra-red radiation is the only external source of heat with which we must contend.

As you can readily see, the conditions of space are encountered, not all at once, but in a stepwise fashion, beginning as low as ten miles and ending at 120 miles. This, then, is the area of partial space equivalence. Between 120 and 600 miles, although still within the physical limits of the atmosphere, lies the area of total space equivalence. Pause

Near the end of World War II, jet planes were introduced over Europe by the German Luftwaffe. The jet represented the first application, in aviation, of the reaction motor which makes use of Newton's third law of motion. The law states that for every action there is an equal and opposite reaction. The jet engine is the transition device between the piston engine and the rocket engine. Reciprocating and jet engines both depend on the supporting air for the oxygen necessary for combustion of the fuel. The rocket carries its own supply of oxygen, [as well as its fuel,] and is completely independent of the atmosphere. In fact, it functions best in a vacuum.

The rocket principle is far from new - the Chinese first made sky-rockets centuries ago. The foremost pioneer in rocket propulsion in this country was Dr. Robert H. Goddard, who began his work as early as 1916. It was not until World War II that the application of his data was used for other than experimental purposes. The bazooka of the U. S. Army and the V-2 of the Germans are early examples of applied rocketry. Since World War II, progress in rocket propulsion has been almost exponential, and the present "state of the art" is only the beginning.

Since the days of the first powered flight by the Wright brothers, progress in aviation has been so rapid with regard to speed and altitude, that human frailty was found to be the chief factor which threatened to hinder ~~further~~ progress. The need for study of the human factors in flight was recognized, early in the History of Aviation and a special school was established for this purpose. The U.S. Army School of Aviation Medicine came into being in 1921 at Mitchell Field, New York, and in 1931 was moved to Randolph Field, Texas.

Because of ~~such~~ the rapid progress in aeronautics and in rocket propulsion, Major General Harry G. Armstrong as Commandant of the School of Aviation Medicine, in 1949, established the Department of Space Medicine. Aviation Medical research has played an important part in the development of aviation during the past 40 years, and has now ~~will continue to do so to an even greater degree,~~ become ~~become~~ even more important in the preparation of man for space flight.

This rapid development of aviation, which has carried us beyond the brink of space, necessitates a revision of our concept of the stages of manned flight, especially with regard to the present and future stages. The revision is illustrated in this slide.

Many of the problems involved in this classification are extensions of those already encountered in present-day operations. These include acceleration, deceleration, oxygen supply and pressurization; but, in addition there will be many new problems not heretofore considered to any great degree in manned flight. These are climatization of a sealed cabin, carbon dioxide removal, new visual problems, physiological and psychological effects of weightlessness, waste disposal, and protection from meteors, solar and cosmic radiation. Day-night cycle, toxicity of rocket fuels.

What other medical problems will be encountered in the evolution of space flight? Man already has been well into the space equivalent portion of the atmosphere, in both balloons and in planes. Capt. Iven C. Kinchelow of the Air Force Flight Test Center, Edwards Air Force Base, California, flew the X-2 to a height of 126,000 feet, or 24 miles. This is double the altitude record for manned

A few weeks ago, Major Dave Simons spent 32 hours at the edge of Space, in a sealed gondola, suspended by a balloon.

craft at the end of World War II. A last summer news item stated that an unmanned three-stage rocket has now reached the physical border of the atmosphere and has attained a speed of about 15,000 m.p.h. And now, since 4 Oct. "Sputnik" has been orbiting earth at >500 mi. Will man be able to withstand the stresses of such rocket flights? Do we know all the human factors involved, or are there some still unknown to us? The Vanguard satellite programs of the I.G.Y. should provide data to fill the gaps in our knowledge. Space Medicine research must provide the engineers with human factors data before they are ready to build a man-carrying rocket. pause

Slides of Sealed cabin + Algae tank

Perhaps the medical problems involved can best be illustrated if you will embark with me on an imaginary flight in a winged rocket to - let us say - Rome, Italy. Our takeoff point is the Denver Spaceport!

All is ready! The hatches are closed - the few remaining items on the pre-flight check list are completed. After a briefing on the flight procedures, you recline in your contour seat just as the warning signal comes on. The fury of the rocket motors is unleashed. You experience the first factor - noise and vibration. As the power is increased the noise would be deafening, if You had not been provided with protective devices for your ears.

As the ship begins to move you notice the second factor--a giant hand seems to be holding you firmly in your seat. This is the force of acceleration, which is expressed in G's. One G is the force of gravity acting upon any body within the earth's gravitational field. The force now holds you tighter and tighter in your seat, as the acceleration increases and you are subjected to 4 G's.

You will not weight more than 600-700 lbs during take-off, because in this passenger ship a liquid propellant is used. The acceleration obtained with a liquid fuel is less than that obtained with a solid fuel. This approaches 15 G's, which is ordinarily more than the human can tolerate. Liquid propellants are stored separately from the oxidizers, while solid fuels contain the oxidizer in combination with the fuel, and burn at a higher, uncontrollable rate. Freight rockets will use solid propellants.

The flight will last about 40 minutes, so the acceleration will continue for only about 12 minutes. As the ship's velocity increases, the noise decreases. Speed increases to about 10,000 mph and the weighty feeling continues until motor cutoff. Suddenly, you feel normal in weight - no! you feel light - light as a feather! You feel that, without the restraint of the seat belts, you would be floating. And so you would be! It is a pleasant sensation, once you recover from the change from several G's to weightlessness, or O-G. At first you feel as if you are going over the top on a roller coaster, but after your interior becomes stabilized, you don't seem to mind at all. You rather like it.

Now you begin to look about you at your companions to observe their reactions. They are looking at you. You see expressions of relief and amazement. Suddenly, everyone begins talking at the same time.

Someone says "Let's look outside." But you remember the smoked glasses which you were given before takeoff, and the instructions which came with them, too. As an added precaution the ports have been covered with shutters and these are opened after you have all put on the smoked glasses. Now you can look at the sun and see the bright disk with its sharp edges.

The co-pilot, over the speaker, says that you may remove your dark glasses if you do not look at the sun. To do so without the glasses would result in permanent damage to the retina of the eye. You can see the stars and the moon, and marvel that they can be seen with the sun in the sky, too. You look back at the earth.

slide

It appears to be lighted by a huge flood light in the dark sky; you are looking down on the bright clouds and through them you can see the blue ocean and the eastern coast line of the United States.

As the initial excitement begins to wear off you settle back in your seat. In doing so, you notice that only the slightest effort is required for any movement of your arms or legs. You raise your arm experimentally. If it were not attached to you, it would continue to the ceiling of the cabin. It remains elevated with no effort on your part, + a slight muscular effort is necessary to bring it back down.

Now you begin to notice the cabin environment. The air is quite fresh - you have no difficulty in breathing, although the ship is now 70 miles above the earth and the cabin is pressurized at an 18,000 foot equivalent. The oxygen in the cabin air is at 42 percent, providing you with the same amount that you would have at sea level. Carbon dioxide produced by the passengers is removed by a chemical absorbent, as the air is circulated. It is filtered through activated charcoal filters, and maintained at a comfortable temperature and humidity.

All these factors are automatically controlled in the climatization of the sealed cabin. It is no problem to carry enough oxygen on short flights from point to point on the globe, or to the large satellite which one day will be circling the earth in its orbit one thousand miles above the surface. Only in flights of more than a week or so will the oxygen supply be a problem.

Now the ship has reached an altitude of 100 miles and a speed of about ~~8,000~~ [12,000] m.p.h. (M-16). [Here we are, shooting through Space!] The flight path has been that of a ballistic missile, since motor cutoff. We now begin to fall back to earth. You have no sensation of falling, however, because you have been weightless for some time, and are still in zero-gravity. As the ship descends to about 40 miles you feel a slight deceleration as when the driver of an automobile applies the brakes. This ~~deceleration~~ is caused by the slowing of the ship due to increasing air density. Speed brakes on the wings of the ship are opened to hasten deceleration. You are [now] in the ~~sitting~~ [reclining] position, ~~now,~~ with the back of your seat toward the nose of the ship. As we approach the earth, the decelerative force becomes greater, and the speed is soon less than Mach 3, or about 2,000 m.p.h. G-force, however, ~~is~~ [has] not greater than ~~3~~ [4]. Still decelerating, the pilot sets his glide path for the Rome space-port, although the ship is still over southern France.

During descent the ship has withstood aerodynamic heating caused by friction with the air molecules. The skin of the ship glowed a dull red, but the cabin was not uncomfortable because of excellent insulation and air-conditioning. Friction heating is not a problem on take-off because the ship passes through the denser layers of the atmosphere at relatively slow speeds, and is soon in the thin, upper atmosphere, where friction becomes less with increasing altitude.

Now the ship is landing. This procedure is very much like the landing of an ordinary air liner, and you are once again on terra firma.

On short flights such as this, protection from cosmic rays and solar radiation is provided by the ship itself.

These, then, would be your experiences during such a flight. On journeys to outer space, as to the Moon or Mars, most of the problems in flight would be exactly the same as those encountered during this short, space-equivalent flight. At this point I'd like to present a film which shows a few of our experiments in zero-gravity at the School of Aviation Medicine, and one carried out at Holloman Air Force Base, New Mexico. In this film you will see the behavior of gases, liquids and various animals in the zero-gravity state.

<u>M-O-V-I-E</u>   Instrumenting F-94 C for further studies

~~Slide 23 — Sealed cabin studies~~

~~Slide 25~~

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Following the flight of animal rockets to higher altitudes, and ~~the successful~~ further launchings of unmanned satellites, small animals will be sent up in larger satellites. When these animals have been kept alive in such vehicles and brought safely to earth again, we should know all the human factors involved in orbital space flight, and plans for human satellites can be completed. Once man has participated in orbital flight and returned safely to the surface, it will be possible for him to venture into outer space and try for the Moon.

The selection of space crews will be the most complex task of this nature yet presented to Air Force psychologists and psychiatrists. The first crews will most certainly be chosen from volunteers among the pool of highly trained jet and rocket plane test pilots, who are accustomed to flying new and untried experimental craft. These ~~men~~ are all highly motivated ~~individuals~~ men who are endowed with an unusual combination of caution and daring in their flying. ~~They are able to put all thoughts, other than those of the task at hand, from their minds. These attributes were not born in them, but rather were developed through the long years of their flying experience, as a result of the handling of emergencies, and tactical situations which require accurate, split-second decision.~~ They are ~~the~~ men who learned early in the game that the hot pilot may be the dead pilot, and who have ~~survived~~ outgrown any foolhardy tendencies they may have had as neophytes. [No man can be all this unless he possesses the inner equanimity which is found in the mature, emotionally well-adjusted person.] ~~These pilots~~ They will have to be their own instructors, and will form the nucleus of the pool of instructors who will train future space pilots. They will also have to be well-versed in the physiological and medical problems of space flight.

The selection and training of space crews who will operate in the more distant future, should begin now, at the early college level. It should be determined by means of questionaires and aptitude tests, which students are most interested in space flight sciences, and from this group selections for space crews can be made on the basis of physical fitness, the ability to withstand ~~special~~ the required stresses, emotional maturity, a preference for teamwork, exceptional learning capacity, and special aptitudes in the sciences necessary as a background for space flight. A good sense of humor also would be an necessary quality to possess. No extraordinary degree of physical strength seems indicated at the present time. Tolerance to special stresses may be much more important. Applicants who are rejected for physical or psychological reasons, could continue their education in scientific fields which are supportive to actual space flight.

Following the selection of these candidates, their academic training should be directed toward ~~an~~ a basic engineering degree with emphasis on mathematics, electronics, nuclear chemistry and physics, astronomy, and related subjects. During this phase of training, the candidates should undergo testing for their ability to withstand certain physical and mental stresses, and at the same time participate in a carefully supervised physical fitness program. After graduation, flying training can begin and progress to include advanced simulator training and test piloting of experimental craft, before the trainee becomes a full-fledged space pilot. This phase could include, complete instruction in the medical problems involved.

~~It appears that~~ It ~~might~~ may be advisable for the space cadet to assist as an engineer in the design of his spaceship, so that he can "grow up" with the ship. In so doing he will have a complete knowledge of its structure, and of the function of each part. Thus, he will be better equipped to cope with any emergency that might arise. Early crewmen will be cross-trained in all positions aboard, and are likely to be the most "multi-trained personnel" in existence.

Space flight is here now. Space travel is still in the future. How far in the future? This, of course, is dependent on our technology! [~~Predictions are always hazardous, but according to estimates of the best authorities we might expect to see manned rockets in 5-7 years; a manned satellite in 10-15 years; a lunar voyage in 15-20 years; Interplanetary travel in 25-50 years. These figures may prove to be conservative!~~] Astronautics and related space flight sciences have already been incorporated into the curricula of some of our universities.

The present state of our technology in the field of astronautics is only the beginning. The rising scale of activity in rockets and missiles is preparing the way for man's greatest technological revolution and undoubtedly the greatest adventure in all his exciting history. The ~~military~~ strategic importance of this revolution cannot be over-estimated! It is essential that an all-out research program be continued in the area of Space Flight, lest undesirable nations gain control of the Spaceways. ~~Yours is a challenging role! You who are Air Force Academy undergraduates to day will play a dramatic part as the Officers in Command, in the development of Space Operations--tomorrow!~~

James G. Gaume, M.D.

JGG/mbn

Speech to be given on 20 June 1957
at Air University-Maxwell AFB, Alabama
to AF Academy Class of 1958.

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It is evident that human factor interests and research must keep abreast of or ahead of engineering progress, or ~~total development will lag.~~ manned space operations will be delayed.

I have given you only a brief resume of the problems and the challenges which confront us in Space Medicine, but I hope that I have contributed to a better understanding of the areas involved in Space Operations, which are in progress, even now.

JAMES G. GAUME, M.D.

Speech given to
Travis County Medical Society,
at Austin, Texas, on
20 November 1956 at 2000 hours.

The importance of space operations cannot be overestimated - scientifically, militarily, or commercially. The benefits to all [of] mankind resulting from the exploration of space will be greater than all the relatively feeble terrestrial explorations to date.

~~For this reason~~ It is essential that an all-out effort be exerted by the United States to lead the technological development of all forms of space operations. No barriers remain that can keep us from the planets-----if we have the will and the ambition to go there.

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