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MAN'S FLIGHT INTO SPACE

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Since man first looked upon the Moon, and discovered the existence of other planets in the heavens, he has dreamed of travelling someday to ~~those~~ these celestial bodies, to explore them and to satisfy his innate curiosity concerning the unknown. Because of ~~the~~ 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 ~~can view~~ could explore them ~~as though from a relatively close distances~~ visually. The development of other instruments has enabled him to gather further information about the sun and planets with regard to their composition. ~~of their atmospheres or surfaces~~. Through the centuries, he has improved these devices to ever greater perfection, and has discovered that those tiny points of light in the night sky, which he had called stars, are actually suns similar to ~~our~~ his own sun and beyond ~~our~~ his own solar system. ~~He has discovered~~ further, that myriads of these suns were grouped together in what seemed to be an isolated cluster in the heavens, and he has ~~called~~ named this cluster a galaxy. A greater surprise was given man when he discovered [subsequently] that many of the "stars" which he thought to be part of our galaxy, were actually other galaxies so far away that they appeared no larger than single stars! The most staggering discovery was that millions of galaxies exist, each composed of billions of stars and separated from each other by a million or more light years of intergalactic void!

Just suppose that some time in the future, we find that galaxies hold a place comparable in the cosmic pattern to the stars, or suns, in our own galaxy! Who, then, could draw a mental picture that would depict the actual size of the universe? And now, the existence of an anti-universe, or mirror image of our own has been postulated!

The effect of these and other discoveries which were made concomitantly, was to whet man's dreams of actual space exploration.

It is doubtful whether man ever will venture into intergalactic space or even into intergalactic space or even into interstellar space within our own galaxy, although it may be argued by some that this is a remote possibility, should we be able to endow our future space ships with the speed of light. However, space operations within our own solar system are rapidly becoming a definite reality. Indeed, it has been said that man is already flying in space.

If this ~~be so~~ is true, it immediately becomes obvious that a definition of space is necessary. The definition is dependent upon the one who is defining the word. Space to the astronomer begins at the ~~upper physical border~~ material limit of the atmosphere, or in the area of 600 miles from the Earth's surface. To one dealing with the human factors in flying and with aerodynamic flight, space may be defined as that area which lies beyond the physiologically and physically effective portion of the air ocean atmosphere ~~which surrounds the Earth~~.

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, at various levels there occurs the loss of all the functions of the atmosphere, insofar as man and aerodynamic flight are concerned. The first function is lost 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, albeit absorbed from the air.

At 63,000 feet, the barometric pressure is so low that body fluids are no longer kept in the liquid state, but vaporize as does boiling water, forming bubbles even at body temperature. These bubbles can snuff out life in a few seconds. The new term -EBULLISM- has been given to this phenomenon, to replace the term "boiling of the blood" which connotes the application of heat.

These two, the oxygen and pressure borders, are called 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 reached at various higher altitudes. Thus, as the barometric pressure decreases, at 70-80,000 feet the pressure is so low that we are no longer able to use ambient air to pressurize the cabin of a craft. 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 acceptable levels would require equipment that would be prohibitive in size and weight.

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 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. Without compression, this concentration is quite toxic to humans, and destructive to equipment, especially rubber and plastics. With adequate compression, 6 ppm would be increased to 60-80 ppm. and would necessitate a device to destroy ozone.

4. In travel beyond the effective atmosphere, the ship will pass through the useful 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 it would be above 80,000 feet.

5. In addition, 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 contaminated immediately upon flying into the area.

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

Pause

Under physical borders can be included also the protective functions of the atmosphere. Factors which arise from beyond the atmosphere, and 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 a shower of secondary radiation particles. These in turn strike other air molecules and the process is repeated, with an accompanying loss of energy with each successive collision. The attenuation of the energy of primary cosmic rays by the air protects us from their potentially harmful effects.

At 140,000 feet the ultra violet 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. The infra-red of solar radiation warms the air and the terrific heat of the sun is dissipated before it reaches us on the ground. Thus we are protected from solar radiation, too.

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 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 400,000 feet (75 miles) sound audible to the human ear will no longer be transmitted, because audible sound requires a medium sufficiently dense for transmission. Above this level the mean molecular pathway of the air molecules becomes greater than the wave length of audible sound. The higher frequencies with shorter wave lengths will disappear first, followed by lower and lower frequencies. This results in the 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 the visible spectrum. So, at 80-100 miles the sky is black, and the stars and moon are visible beside the sun.

The last physical functional border lies at about 120 miles. Above this point, a craft moving at any speed ceases to obtain "lift" from the air and there is no longer friction heat or its transfer to the interior of the vehicle. Above 120 miles solar infra-red radiation becomes the most important 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 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.

Toward the end of World War II, jet planes were introduced over Europe by the German Air Force. 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 reciprocating engine and the rocket engine. The jet engine depends on the supporting air for oxygen necessary ~~in~~ 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. 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. — He began his work as early as 1916, but it was not until World War II that application of his data was used, other than experimentally. The bazooka of the U. S. Army and the V-2 rocket of the Germans were [the] 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 human factors in flight was recognized, and a special school was established for this purpose. The Army School of Aviation Medicine came into being in 1919, at Mitchell Field, N.Y. as the School for Flight Surgeons.

This field of medicine is now a certified specialty under Board of Preventive Medicine.

Because of such 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 will continue to do so to an even greater degree, in the preparation of man for space flight.

This rapid development of aviation which has carried us beyond the brink of space, has necessitated a revision of our concept of the stages of manned flight, especially with regard to the present and future stages. This 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 control, new visual problems, physiological and psychological effects of weightlessness, waste disposal, and protection from meteors, solar and cosmic radiation.

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. Kincheloe of the Air Force, Flight Test Center, flew the X-2 to a height of 126,000 feet, or 24 miles. This is double the altitude record for manned craft at the end of World War II. A recent news item stated that an unmanned three-stage rocket has now reached the physical border of the atmosphere and has attained nearly orbital velocities of 17,00-18000 mph. [How long will it be before a man-carrying rocket with a sealed cabin can be built? Will a man be able to withstand the stresses accompanying a rocket flight?] Do we know all the human factors involved, or are there some as yet unknown to us? The I.G.Y. satellite program should provide data to fill the gaps in our knowledge. ~~We~~ Space Medicine researchers must provide the engineers with human factors data before they are ready to build a man-carrying rocket.

Perhaps the medical problems involved can best be illustrated ~~by~~ if you will [coming] embarking with me [embarking] on an imaginary flight in a winged rocket to - let us say - Rome. Our takeoff will be from the New York Spaceport.

All is ready! The hatches are closed - the few remaining items on the pre-flight check list are [clocked] checked off. You are reclining in your contour seat 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 becomes deafening. You are very thankful that you have been provided with ~~noise dampers to~~ protection for your ears.

As the ship starts to move you begin to feel the second factor - a giant hand seems to be holding you firmly in your seat. This is the force of acceleration, which we express~~ed~~ in G's. One G is the force of gravity acting upon any body within the earth's gravitational field. The hand holds you tighter and tighter in your seat, as acceleration increases. ~~until you feel you must weigh a ton - and maybe you do - anyway, half a ton.~~

You will not weigh more than half a ton during takeoff, because in this passenger ship a liquid propellant is used. The G-force with liquid fuel is much less than with a solid ~~propellant~~ fuel. The Liquids contain less energy per unit of weight than do solids, which also contain the oxidizer in combination with the fuel. Freight rockets will use solid ~~fuels~~ propellants.

The journey is only about 3,000 miles and will last about ~~30-60~~ 40 minutes, so acceleration will continue for only about 12 minutes. As the ship's velocity increases, the noise decreases, but the weighty feeling continues until motor cutoff. As the motors are cutoff, + we coast upward. All at once you feel normal in weight - no! you feel light - as a feather! You feel that, without the restraint of the seat belts, you

how far up?

would be floating. And you would be! It is a ~~very~~ 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, too. As an added precaution the ports ~~are~~ have been covered with ~~Venetian~~ shutters and these are opened when you have all put on the smoked glasses. Now you can look at the sun and you see the bright disk with its sharp edges.

The co-pilot, over the speaker, says that you may remove your dark glasses if you ~~first~~ do not look ~~away from~~ at the sun. 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. It seems to be lighted by a floodlight in the dark sky; you are looking down on the white clouds and through them you can see the blue ocean and the eastern coast~~al~~ line of the United States.

As the initial reaction 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 it would continue to the ceiling of the cabin. It remains elevated with no effort on your part.

You begin to notice the cabin environment. The air is quite fresh - there is no difficulty in breathing, although you are now about 60 mi high, 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 as you would have at sea level. ~~The inert gas in the atmosphere is nitrogen.~~ Carbon dioxide produced by the passengers is removed by a chemical absorbent, as the air is circulated. It is filtered through ~~xxx~~ 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 will one day be circling the earth in its orbit one thousand miles above the surface. Only in flights of a number of days or weeks will oxygen supply be a problem.

~~Such is the case in the satellite itself. Because it circles continuously without coming to earth, oxygen will~~

need to be replenished. This can be done when supplies are ferried to the satellite.

Perhaps another means of providing O_2 will be with the use of an oxygen-carbon dioxide exchange system. Such a system is photosynthesis in green plants. Plants, in presence of sufficient light, absorb carbon dioxide from the air and give off oxygen to the air. Basic research in this area is being carried out under Air Force contract by Dr. Jack Myers at the University of Texas. Dr. Myers has found that five pounds of the common alga Chlorella pyrenoidosa is sufficient to balance the respiratory cycle of one man. In other words, under proper conditions, the algae will give off enough oxygen to sustain one man, and will absorb the carbon dioxide produced by one man. This method of gas exchange is still under study for possible future applications.

Algae have also excellent air potentiality as a food source. A number of researchers in Japan and this country have been working for a number of years on algae as a food supplement. Algae have been found to contain very good quality of protein, some fats, carbohydrates, and most of the vitamins necessary in our diet.

Let's get back to our flight. We have reached an altitude of 100 miles and a speed of about 12,000 mph (M-16). Our 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 ~~25-30~~ 50-60 miles ~~there is~~ you feel a slight force pushing you forward, as when the driver of an automobile applies the brakes. This force is deceleration, caused by the slowing of the ship due to ~~the~~ increasing air density. Speed brakes are opened on the wings ~~of the ship~~ to hasten deceleration. You are in the sitting position, now, with the back of your seat toward the nose of the ship. As we ~~get closer to~~ approach the earth the decelerative force becomes greater, and the speed is soon less than Mach 3, or about 2,000 mph, still decelerating. G-force, however, is not greater than 2. The pilot sets his glide path for the Rome space-port, although the ship is still over southern France.

During the descent, the ship has withstood aerodynamic ~~friction~~ heating ~~encountered in reentry of the earth's atmosphere.~~ caused by friction with the air. 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.

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. However, the nose of the ship and leading edge of the wings show some scarring as if they might have been sand blasted. Such is the effect of the micrometeorites present in the upper atmosphere.

Admittedly, I have let my imagination run freely in this description, but these would be your experiences during such a journey. On longer space journeys, one would encounter the same, and other problems, dependent on the destination. To illustrate the story more vividly, I'd like to run a movie showing almost the same sort of flight, but shorter, with animal passengers.

<u>**M O V I E**</u>

There is another important human factor in space flight. As you know, all life processes occur in cycles or rhythms. The most significant is the physiological day-night cycle, which is characterized by rhythmic changes in bodily processes such as respiration, digestion, circulation and cellular metabolism. These changes are closely related to the physical day and night caused by the rotation of the earth. All of you know of the adjustment one must make, in changing from a day to a night shift in a hospital, in a factory, or on board ship, or even the change from one time zone to another. The problem of adjustment is just as acute in today's travel by fast plane, across large areas of the globe. Thus, after such a journey, an individual may arrive in time for an important conference in the afternoon, when his physiological rhythm indicates that it is time for sleep and not for alert mental activity. The period required for natural adjustment [in such cases] may be as long as a week for some individuals. Others make a very rapid adjustment. Dr. Kleitmann, of the University of Chicago, in his research on this subject, found that the body can adapt itself, within certain limitations, to changes in the day-night cycle. He and his associates remained for two months in Mammouth Cave, in Kentucky. During this time their cycle of work or activity and rest, recreation and sleep, was varied from less than 16 hours to more than 32 hours. They found that the cyclic rhythm can be maintained in periods as short as 18 hours and as long as 28 hours without significant alteration. Beyond these limits the body will re-establish a rhythm corresponding to that of a more or less normal day. This information becomes extremely important in planning for the crew of a manned satellite. Will it be necessary to plan for three crews working in 8 hour shifts or can two crews operate efficiently on a 2-shift, 18 hour day? The difference in weight alone would be a significant factor.

The physical day-night period in a satellite orbit would be quite different from that on the earth. For instance, Wehrner von Braun, noted German rocket scientist, now in this country, has proposed a manned satellite, circling the earth in an orbit at 1,075 miles. The time required for one revolution of the earth would be approximately two hours at a speed of almost 16,000 m.p.h. Twelve times in 24 hours, the satellite would pass through day and night. The night would occur during the movement of the vehicle through the shadow of the earth, and would be only about 40 minutes in duration. This is assuming that the satellite is travelling around the earth in the same plane as the sun's rays. If the satellite were to circle in a plane at right angles to the sun's rays, there would be no night at all. Therefore, it will become necessary to create an artificial day-night cycle which would correspond rather closely to that of our metabolic clock, if satellite operations are to be efficiently maintained.

I have not mentioned the psychological problems associated with space flight. They will be numerous and varied. It will suffice now to mention only these few:

1. determination of the best combination of personality types to be included in the same crew,

2. responses of different personality types to various stress situations in space operations

3. psychological aspects of visual orientation and of weightlessness in space

4. selection of crew members using like adaptability characteristics regarding day-night cycling as one of the criteria.

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 who are endowed with a peculiar combination of caution and daring in their flying. They are the men who 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 other situations which required accurate, split-second decisions. They are the men who learned early in the game that the hot pilot may well be the dead pilot, and who have survived 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 men 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 crews who will operate in the more distant future, should begin <u>now</u>, at the early college level. It should be determined via questionaires and aptitude tests, who is the 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 stresses, maturity of emotional development, 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 would also be an excellent quality to possess. No extraordinary degree of physical strength seems indicated at the present time. [Special sense characteristics may be much more important.]

Following the selection of these candidates, their academic training should be directed toward an engineering degree with emphasis on mathematics, electronics, nuclear chemistry and physics, astronomy, and related subjects. During this phase of training, the candidates should also undergo testing for their ability to withstand certain physical 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 becoming a full-fledged space pilot. This phase could include also, complete instruction in the medical problems involved.

It appears now that it will be advisable for the space ~~xx~~ cadet to ~~assist~~ participate 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 emergencies that might arise. Early crewmen will be cross-trained in all positions aboard, and are likely to be the most "~~multi~~ cross-trained personnel" in existence.

Space flight is here now! Space travel is in the future. How far in the future? ~~Only a prophet of Nostradamus' caliber might be accurate.~~ According to estimates of the best authorities, I would say--manned rockets in 5-7 years; a manned satellite in 10-15 years; a lunar voyage in 15-20 years. I certainly expect to see it myself! Interplanetary travel - ~~25-50 years~~ probably before the end of the century. I hope to be here yet, when that takes place, too! Astronautics and ~~the~~ related space flight sciences have already been incorporated in the curricula of some of our universities.

Space law is in the embryo stage. To date, no nation has objected to the launching of the satellites and their passage over national boundaries. The reason may well be that all nations feel that they will benefit richly from the knowledge gained through these instruments of research. I fully expect also, that this knowledge, which will result from a cooperative effort of all peoples, will smooth the way for vastly improved international relations, and a lasting peace on earth.

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