Dr. Strughold has made a comparison between the terrestrial atmosphere, as a closed ecological system, and that of the Space Cabin Simulator. The only difference between the two is in size. Their functions are exactly the same, insofar as human life is concerned.

Our problem is to create such an artificial, closed ecological system in miniature, with automatic regulating devices, which will substitute in the role of the earth's atmosphere. The reasons for such a cabin in future spacecraft have already been mentioned. Technically, the compression of ambient air at the 70-80,000 ft level, with present-day equipment would be extremely difficult, due to the low air density, and the size and weight of the compressors required. Air density at 80,000 feet is only 1/30th of the air density at sea level. Were it possible to use ambient air, the cabin air temperature would be elevated to approximately 400°F. At the same time, toxic concentrations of ozone would be introduced into the cabin. Ozone is normally present to the extent of 5-6 ppm at 80,000 feet. This amount is already quite toxic in a matter of minutes, and to multiply this by the necessary compression factor would result in extremely high concentrations. Finally even in shorter, global space flights, the length of time that would be spent in the portions of the atmosphere usable for this purpose, would be only a matter of minutes. To carry such heavy machinery for so short a useful time would be entirely impractical. It would be much more simple to provide a sealed cabin from the ground up.

Another technical problem is the pressurization of the cabin at a pressure ~~that~~ which will be acceptable physiologically, and at the same time be acceptable to the engineers. An ~~physiological optimum~~ agreeable pressure would be near 10 psi or 10,000 ft [or 520 mm Hg.] but from the structural point of view, this might be difficult. We shall have to relinquish, therefore, certain physiological comforts and direct our research efforts toward the determination of the ~~body's capacity to function~~ means necessary to maintain efficient bodily function in a sealed cabin at a pressure differential of 7 psi or 18,000 feet [or 380 mm Hg]. Should a higher pressure differential be feasible, all well and good. Cabin pressure of half an atmosphere would be acceptable ~~for~~ to the crew, if a 40% oxygen environment were provided.

In order to maintain a constant pressure of 7 psi within the cabin, an absolutely leakproof compartment is desired. If this is not technically possible, a minimal + controlled leakage will have to be tolerated. The Space Cabin Simulator was constructed to permit a leak of not more than .1 psi per hour, at 18,000 feet. This corresponds to a loss of altitude of 360 ft/hr or a barometric rise of about 7 mm Hg. ~~On~~

On checking the cabin, we found that the leakage was 1.85 psi/hr. at 18,000 feet, or nearly twenty times that of specifications. We found that nearly every opening in the cabin, with the exception of the small lock doors and the outer door, had significant leaks. Leaking most ~~especially badly~~ were the ports through which entered the inter-com lines, the oxygen line, and the compressed air inlet valves. We redesigned ~~some of~~ the intercom xxxx and oxygen seals and disconnected the compressed air lines. All unused openings were resealed, the glass ports were removed and resealed. The leak rate was then slightly more than .1 psi/hour. Then we began to increase the leak potential by adding leads for the thermocouple recorder, the barometer and air sampling device, and for the Sanborn recorder used for observation of cardiac and respiratory activity of the subject, especially when he was sleeping. Even with these additions, the leakage rate is now only .03 psi or 1/3 of that called for in the specifications. We didn't discover the compressed air line leak until after the 24-hr exp. This small leakage will permit us to conduct our experiments satisfactorily. The oxygen regulating mechanism, which will be discussed in detail by Dr. Roth, is dependent upon very small pressure changes in the cabin. Hence, it can be seen that any significant leakage of air into the cabin will affect, adversely, the rate of oxygen flow. When we finished the analysis of the results of the 24-hour experiment, we found that the marked oxygen drop was the result of excessive leakage. Before the experiment, the leakage rate was .18 psi/hr. This demonstrates adequately, the necessity of a leakproof cabin, since oxygen control mechanisms in actual space cabins may also depend upon minute pressure changes.

Another reason for this necessity is that air entering the cabin from the outside will alter the quantitative analysis of the gases within. These values would be changed again, if it were necessary to remove cabin air via the vacuum line in order to maintain the proper ~~altitude~~ cabin pressure. Of course, in actual space situation, the pressure differential would be reversed, and the leakage would be in the opposite direction.

In the last experiment, the temperature built up to a maximum of 31.5° C, in 6½ hours, and equilibrated at 31°C, thereafter. Sources of heat in the cabin were the subject, who produced heat equivalent to that of a 100 W bulb, two blowers of 70 W each, a small blower for the wet bulb thermocouple, and a 100 W bulb for light. The inside temperature stabilized at 31° C(88°F), due to the loss of heat by radiation, from the walls of the chamber to the outside air. This temperature is not severe, but becomes

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annoying when coupled with the high humidity which developed. The relative humidity built up to a peak of 95% in 3½ hours. We attempted to control the humidity by means of a silica gel unit attached to a blower, but apparently not enough circulation of air through the unit was obtained. Although this high humidity had a greater affect on ~~Smith~~ the subject than would the high temperature alone, no unduly harsh effects were noted.

Another method of controlling humidity is with the use of magnesium perchlorate as the absorbing chemical. This is more efficient than silica gel, but when both of these chemicals absorb moisture, the moisture is not recoverable. Our future plan is to utilize the air conditioning system to control both the temperature and the humidity as illustrated in this slide. (S L I D E) Slide 2.

Slide 2

Getting food and drink to the subject during these experiments presents no special problem. The small lock on the round portion of the chamber is utilized for this purpose. (S L I D E or D I A G R A M) In order to minimize changes in the cabin air during this procedure, the food is placed ~~in the lock~~ next to the closed inner door. Then a large balloon is placed in the lock and inflated until it fills the remaining space in the lock. The outer door is closed, the subject opens the inner door and removes the containor. If there are wastes to be removed from the chamber, he places the waste receptacle in the lock against the balloon and closes his door. The

Slide 2A

outer door is opened, the balloon is deflated and the objects removed. If the cabin is at altitude, the balloon need not be inflated completely, since the reduction of pressure in the lock to equal that in the cabin, will inflate the balloon further and fill the remaining space.

Eventually, other means will be provided for the handling of human excreta. Air Force contracts are now in force for the development of a urine evaporator and a stool incinerator. We plan to do studies on evaporation of urine in our next series of experiments, re-cycling the water vapor with the other moisture in the cabin. In interplanetary craft and in manned satellite vehicles, the cabins may possibly be equipped with algae units which will not only produce oxygen, and take up CO_2, but will dispose of organic wastes. After suitable processing, the organic matter could serve as food for the algae which in turn would grow in excess of the amount needed to produce the crew's oxygen requirements. This excess could be harvested, processed and used as a food supplement for the crew. Such a unit would bring closer to reality a self-sustaining, closed, ecological system, more completely reproducing our terrestrial system.

Since this chamber with its metal walls, has an extremely poor capacity to absorb sound waves, noise factors become very important to the subject confined therein for periods of days or weeks. In the studies thus far, several sound problems have been observed:

1. The blower for the wet bulb thermocouple has a disagreeable whine;

2. The CO_2 absorber has a lower tone which is less ~~not so~~ disagreeable;

3. The pitch of the air conditioning blower to be installed has not yet been determined, ~~as yet~~.

Studies will be done in the future on psychological effects of various vibration factors. With this in mind, the resonant frequency of the chamber was determined. The frequency was found to vary from 410 cps, or A-flat, in the large end of the chamber, to 320 cps, or E, in the small end. The reason for this is the variation in size and shape of the two parts of the unit. This presents a greater noise problem than would a chamber with a regular shape ~~morphology~~, because of the many overtones resulting from ~~of~~ multiple frequencies instead of from only one frequency. In experiments of shorter duration such as 24 hours, the effect might not be too serious, but in longer ones the continuation of these sounds might be devastating to some individuals. Engineers are having considerable difficulty in damping out some frequencies in rockets. But--on the lighter side--this cabin is a veritable bonanza for the man addicted to singing in the shower. The reverberations are wonderful. Any of you are welcome to use it for practice!

Not the least, are numerous psychological factors which will be encountered. Some of these are:

Stress reactions associated with

Noise factors, as was just mentioned, and their effect on mental capacities

High temperatures and humidity. Also, perhaps very low temperature and the sudden change from one to the other

Claustrophobic tendencies

Effects on one individual of the body odors of the other crew members

Work capacities under various stress situations

Responses of different personality types to the various factors to be encountered in space flight

The best combination of personality types to be included in space crews

The effects of the realization that one is "alone in space" so-to-speak, and the anticipation of a rocket-ship landing on either the earth or another heavenly body.

The psychological aspects of visual orientation in space

The results of changes in the day-night cycle

These are only a few -- many others will appear as new facts and knowledge of space is acquired.

I have reviewed ~~some of~~ the physical problems which we have encountered in our experimentation with the ~~sealed~~ space cabin simulator, and have made brief mention of some of the psychological aspects of space flight. Dr. Roth will discuss the other phases of our experimental program.

Dr. Roth.