TECHNICAL SESSION I

ALGAL GAS EXCHANGE SYSTEMS

Chairman

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THE ALGAL PHOTOSYNTHETIC GAS EXCHANGER

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It seems proper to begin this symposium session with a brief look at the eleven year history of its subject. While it is always dangerous to date the inception of some general concept, I shall mark this point with the lecture of Dr. Heinz Specht at the 1951 Air Force Symposium on the Physics and Medicine of the Upper Atmosphere. For management of the human respiratory requirement in a sealed cabin, photosynthesis of a plant was suggested as a possible solution. The suggestion did not invoke any new principle. Essentially it went back to the experiments of Joseph Priestley in 1775.

The idea of a photosynthetic gas exchanger certainly was and is sound in principle when phrased qualitatively. But how would it look quantitatively? The second stage question had to do with estimates of feasibility. Is the photosynthetic gas exchanger really a sensible way to solve a part of the space biologistics problem? A number of people interested in the problem began trying to reach some quantitative answers from already available data. We got beyond the pumpkin leaves which had been a part of the original suggestion. We mastered the concept that long-time performance in the gas exchange of any plant is a special steady-state condition not necessarily estimated correctly from short-time measurements of photosynthesis. We recognized that in steady-state operation there must be a stoichiometry between oxygen production, carbon dioxide utilization, and production of organic plant material. And we came to a general conclusion that of all plants the algae offered a number of special advantages.

The second stage question, the estimation of performance from previous data, is still going on and still engenders debate. But the guts of the evidence had been worked over six years ago. The ONR Conference on Photosynthetic Gas Exchangers in 1956 arrived at performance estimates which are summarized in Table 1. The performance estimates reached were based upon the judgments of three of the participants, here designated X, Y, and Z since their names are not pertinent to our discussion. The estimates varied within a ten-fold range mainly because of differences in the premises used. The conservative estimates were based on currently available technology; the optimistic estimate was based on what was judged to be a reasonable extrapolation. What performance estimates should we make today?

Presumably we are now in the third stage problem which requires hard-nosed experimental development and testing of

Table 1

Second Stage Performance Estimates for an Algal Gas Exchanger*

(For one man at 600 liters O_2/day)

	ALGAE				POWER
	Working Quantity of Algae (gm.)		Algal Cell Conc.	Specific Growth Rate	Electric Power Requirement for Lights
	Wet Wt.	Dry Wt.	(Vol. %)	(day $^{-1}$)	(HP)
X	2,400	600	1	1.	10
Y	1,000	250	1	2.4	6
Z	240	60	1	10.	1

	VOLUME		RELIABILITY
	Algal Suspension Volume (liters)	Estimated Total Volume (cu. ft.)	Reliable and Constant Long-period Performance
X	230	80	?
Y	100	20	?
Z	25	--	?

*From 1956 ONR Conference on Photosynthetic Gas Exchangers

X, Y, Z represent estimates made by three different participants model systems to see what kind of performance really can be achieved. Unfortunately, this is difficult and not very dramatic work. I do not wish to be critical of any agency or of any one research group. I am sure that each has sound reasons for the choice of questions which it is asking. At the same time I am skeptical whether the important questions of establishing a firm base of performance characteristics are really being answered. There are a number of understandable reasons for what seems to me a diversion of effort. First, there has been a tendency to take some one of the second-stage estimates as gospel. Secondly, there has been an unfortunate belief that establishment of a closed, steady-state ecosystem is an all-or-none problem. There has not been consistent attempt at breakdown into component problems to be treated independently. Thirdly, we have become aware of the increasing complexities and restrictions which must be placed upon systems operating under conditions of a space cabin. We have attempted to solve the complex problems before knowing real answers to the simple problems.

I would like to focus some attention upon the simplest problem. Suppose we phrase a basic third-stage question in this way: what are the minimum requirements and the maximum performance characteristics for an algal gas exchanger? This is not a simple question. Popular accounts to the contrary, the large scale steady-state culture of algae is not easy. The answers will not be uniform since any chosen design will favor certain performance characteristics at the expense of others. But I think it important to inquire what the third-stage answers are to the simple questions.

Accordingly, I have made these remarks and the data of Table 1 available in advance to each of the participants. It is my hope that, wherever possible, they will provide third-stage experimentally determined performance data extending or correcting the crude second-stage estimates.

My remarks have lacked the usual peaches-and-cream complexion of an introduction. And I recognize your just criticism of a chairman who introduces a symposium session on a note which you may regard as cynical. I hope it will turn out that I have overstated the case, that my remarks only reflect ignorance of solid experimental data which are being accumulated. In any event I have cleared the decks for action.