L5 NEWS

August 1979

"Pilgrims, Saints and Spacemen"—
Special Preview of Freeman Dyson's Forthcoming Book
Asteroid Features: Peanut-Shaped, Mined, and Falling

L-5 NEWS

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In this issue:

Cover: This unusual asteroid was recently discovered in the Jupiter/Sun L-5 libration point. See "L-5 Hosts Giant Peanut" on page 6 of this issue. (Painting by William K. Hartmann.)

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An exciting preview of Freeman J. Dyson's forthcoming book **Disturbing the Universe**.

Pilgrims, Saints and Spacemen

Artwork by James Babcock

by Freeman J. Dyson

Governor William Bradford of the Plymouth Colony, President Brigham Young of the church of Jesus Christ of Latter-day Saints, and my friend Professor Gerard O'Neill of the Princeton University physics department have much in common. Each of the three is a man of vision. Each believes passionately in the ability of ordinary men and women to go out into the wilderness and build there a society better than the one they left behind. Each has written a book to record for posterity his vision and his struggles. Each has his feet firmly on the ground in the real world of politics and finance. Each is acutely aware of the importance of dollars and cents, or pounds and shillings, in making his dreams come true.

The histories of Bradford and Young were not printed during their lifetimes but were left in manuscript form for the guidance of their followers. Bradford's manuscript was published two centuries later under the title **History of Plymouth Plantation**. Young's manuscript is quoted extensively, but not in full, in the official history of the Mormon church. O'Neill's book, **The High Frontier**, fortunately did not have to wait for posthumous publication.

The human and economic problems that the space colonists of tomorrow will face are not essentially different from the problems faced by Bradford in 1620 and by Young in 1847. Unfortunately, the extravagant style and exorbitant costs of the Apollo expeditions to the Moon have created in the minds of the public the impression that any human activities in space must necessarily cost tens of billions of dollars. I believe this impression to be fundamentally mistaken. If we reject the style of Apollo and follow the style of the *Mayflower* and the Mormons, we shall find the costs of space colonization coming down to a reasonable level. By a reasonable level of costs I mean a sum of money comparable to the sums which the Pilgrims and the Mormons successfully raised.

The human and economic problems that the space colonists of tomorrow will face are not essentially different from the problems faced by Bradford in 1620 and by Young in 1847.

Bradford and Young provide abundant documentation of the difficulties they faced in raising funds. Bradford emphasizes in his book that the toughest problem in the whole venture of colonization was to define a set of objectives upon which the brethren could agree:

> But as in all businesses the acting part is most difficult, especially where the work of many agents must concur, so was it found in this. For some of those that should have gone in England fell off and would not go; other merchants and friends that had offered to adventure their moneys withdrew and pretended many excuses; some disliking they went not to Guiana; others again would adventure nothing except they went to Virginia. Some again (and those that were most relied on) fell in utter dislike of Virginia and would do nothing if they went thither.

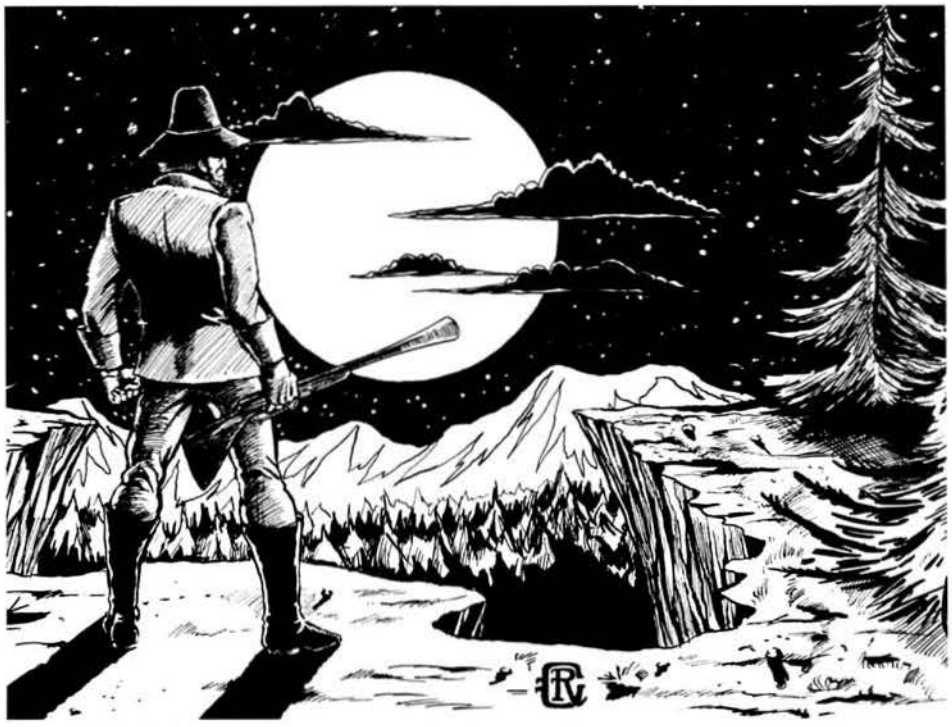
Without agreement upon objectives, the task of fund raising becomes impossible. This is a fact of life which remains as true today as it was in 1620. Bradford and Young devote more pages of their histories to the preliminary battles over objectives and finance than they devote to the description of their voyages. For both of them, it came as a blessed relief when the miseries of indecision were over, the expeditions were

ready to go, and they were finally able to turn their attention away from political and financial matters to the simpler problems of physical survival. Here is Young writing from his winter quarters in February 1847, six weeks before starting his journey across the plains:

I feel like a father with a great family of children around me, in a winter storm, and I am looking with calmness, confidence and patience, for the clouds to break and the Sun to shine, so that I can run out and plant and sow and gather in the corn and wheat and say, children, come home, winter is approaching again and I have homes and wood and flour and meal and meat and potatoes and squashes and onions and cabbages and all things in abundance, and I am ready to kill the fatted calf and make a joyful feast to all who will come and partake. We have done all we could here and are satisfied it will be all right in the end.

But I must come back from these idyllic sentiments to questions of dollars and cents. Two years earlier, Young reported:

For an outfit that every family of five persons would require: one good wagon, three yoke of cattle, two cows, two beef cattle, three sheep, one thousand pounds of flour, twenty pounds of sugar, one rifle and ammunition, a tent and tent-poles—the cost would be about $250 provided the family had nothing to begin with, only bedding and cooking utensils, and the weight would be about twenty-seven hundred [pounds] including the family.



Artwork by Robert Cannon

...it came as a blessed relief when the miseries of indecision were over, the expeditions were ready to go, and they were finally able to turn their attention from political and financial matters to the simpler problems of physical survival.

The arts were also included in Young's budget. On November 1, 1845, he paid $150 to purchase instruments for the brass band. This was a wise investment, for the band

Was sometimes invited to give concerts at villages near to the line of march, which did much to change the feelings of hostility which occasionally was manifested in such places. Thus the band proved a very great benefit to the marching column, besides cheering the spirit of the pilgrims.

The actual numbers that crossed the plains with Young were: 1,891 souls, 623 wagons, 131 horses, 44 mules, 2,012 oxen, 983 cows, 334 loose cattle, 654 sheep, 237 pigs, 904 chickens.

So we can estimate the total payload of Young's expedition to be 3,500 tons, mainly consisting of animals on the hoof, and the total cost to be $150,000 in 1847 dollars.

Bradford unfortunately does not provide such an exact accounting for the *Mayflower*. He quotes a letter from Robert Cushman, dated June 10, 1620, in London, two months before the sailing. Cushman was one of the people in charge of provisioning for the voyage:

Loving Friend, I have received from you some letters, full of affection and complaints, and what it is you would have of me I know not; for your crying out, "Negligence, negligence, negligence," I marvel why so negligent a man was used in the business.—Counting upon 150 persons, there cannot be found above £1200 and odd moneys of all the ventures you can reckon, besides some cloth, stockings and shoes which are not counted, so we shall come short at least £300 or £400. I would have had something shortened at first of beer and other provisions, in hope of other adventures; and now we could, both in Amsterdam and Kent, have beer enough to serve our turn, but now we cannot accept it without prejudice—£500 you say will serve; for the rest which here and in Holland is to be used, we may go scratch for it.—Think the best of all and bear with patience what is wanting, and the Lord guide us all.

Your loving friend, Robert Cushman

This letter shows that Cushman was personally responsible for meeting expenses to the tune of £1500. It does not say whether all the expenses, and in particular the rental fee for the *Mayflower*, were included in this figure.

Three weeks later, on July 1, 1620, an agreement was signed between the Planters and the Adventurers. The Planters were the colonists. The Adventurers were the shareholders who invested money in the enterprise and stayed at home. The agreement stipulated "that at the end of the seven years, the capital and profits, viz. the houses, lands, goods and chattels, be divided equally betwixt the Adventurers and Planters." Another clause of the agreement gave one share to each of the Planters as a bonus for their seven years of hard labor: "Every person that goeth being aged 16 years and upward be rated at £10, and £10 to be accounted a single share." Any cash that the Planters contributed would entitle them to additional shares.

The 1620 agreement proved unsatisfactory to both sides and caused constant friction. In 1626, a year before the planned division of assets, the whole matter was renegotiated and a new agreement was signed, "drawn by the best counsel of law they could get, to make it firm." The 1626 agreement stipulated that the Adventurers sell to the Planters, "in consideration of the sum of one thousand and eight hundred pounds sterling to be paid in manner and form following,—all and every the stocks, shares, lands, merchandise and chattels—any way accruing or belonging to the generality of the said Adventurers aforesaid." Having bought out the Adventurers' shares, the Planters were left with a debt of £1800, which they finally succeeded in paying off twenty-two years later.

I do not know how much profit or loss the Adventurers took in the 1626 settlement. I also do not know how large a fraction of the original cost of the expedition was paid by the Planters. As to the first point, it is unlikely that the Adventurers

took a loss, for the colony was not bankrupt in 1626 and the Adventurers were not in the habit of lending their money for nothing. As to the second point, it is unlikely that the Planters paid as much as half of the original costs. If they had been in a position to pay half, they would probably have managed to squeeze the expenses down to such a point that they could do without the Adventurers altogether and avoid the innumerable headaches that the partnership brought with it. I therefore conclude from the evidence of the 1626 settlement that £3600 is a safe upper limit to the original cost of renting and provisioning the *Mayflower*. The evidence of the Cushman letter implies a lower limit of £1500. I shall adopt £2500 as my estimate of the cost of the expedition in 1620 pounds. This figure can hardly be wrong by a factor of two either way. The payload of the *Mayflower* is stated explicitly by Bradford. It was 180 tons.

...both the Mayflower and the Mormon expeditions were extremely expensive operations. In their time, each of them stretched the limits of what a group of private people without government support could accomplish.

My next problem is to convert the 1620 and 1847 cost figures into their modern equivalents. A good source of information about the history of wages and prices in England is the work of Ernest Phelps Brown and Sheila Hopkins, published in two articles in the journal **Economica** and reprinted in a series called **Essays in Economic History**, put out by the Economic History Society. The first article deals with wages, the second with prices. It is a question of taste whether one prefers to use wages or prices as the basis for comparing costs between different centuries. If we use wages, we are saying that an hour of a workingman's time in 1620 is equivalent to an hour in 1979. If we use prices, we are saying that a pound of butter in 1620 is equivalent to a pound of butter today. My personal opinion is that wages give a truer standard of comparison than prices. My purpose in making the comparison is to try to define in a roughly quantitative fashion the size of the human efforts that the *Mayflower* and the Mormon expeditions demanded.

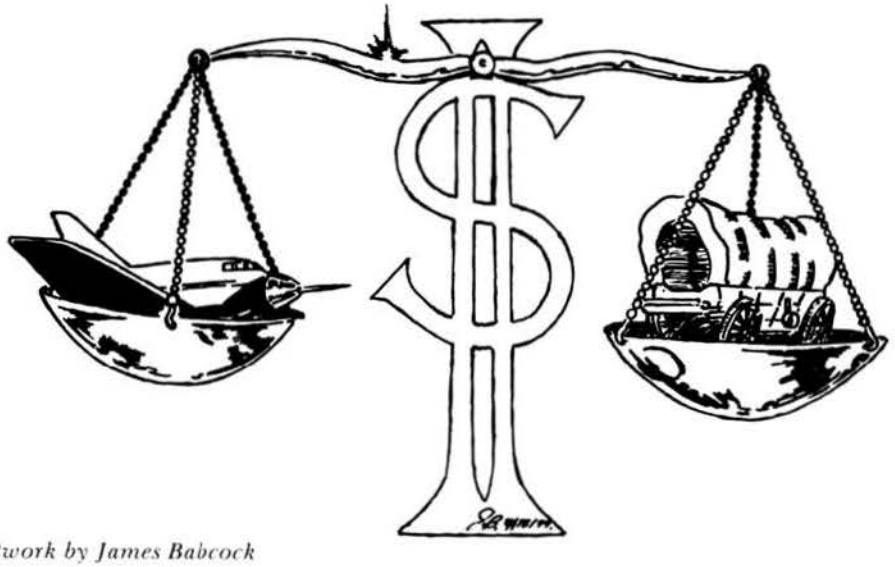
According to Phelps Brown and Hopkins, the wages of workers in the building trade in 1620 were in the range from 8 to 12 pence per day. In 1847 the range was from 33 to 49 pence. For the modern equivalent of these numbers I take the minimum rate of $9.63 per hour imposed by building trade union contracts in New York in 1975. The exchange rates on the basis of wages are then:

£1 (1620) equals $2500 (1975)
$1 (1847) equals $100 (1975)

These are very approximate numbers. A rough check on the numbers for 1620 is provided by the fact, already mentioned, that each Planter received a credit of £10 for going to Plymouth and working for the community for seven years without wages.

The estimated total costs in 1975 dollars are then 6 million for the *Mayflower* and 15 million for the Mormons. On this basis I have drawn up the first two columns of Table 1. The point I am trying to emphasize with these numbers is that both the *Mayflower* and Mormon expeditions were extremely expensive operations. In their time, each of them stretched the limits of what a group of private people without governmental support could accomplish.

The numbers in the bottom row of Table I give an estimate of the number of years an average wage earner would have had to save his entire income to pay the passage for his family. Although the average Mormon family was twice as large as the average *Mayflower* family, the cost in man-years per family was three times as large for the *Mayflower* as it was for the Mormons. This difference had a decisive effect on the financing of the colonies. An average person, with single-minded dedication to a cause and with a little help from his friends, can save two or three times his annual income. An average person with a family to feed, no matter how dedicated he may be, cannot save seven times his income. So the Mormons were able to pay their way, while the Planters on the *Mayflower* were forced to borrow heavily from the Adventurers and to run up debts which took twenty-two years to pay off. Somewhere between two and seven man-years per family comes the breaking point, beyond which simple do-it-yourself financing by ordinary people becomes impossible.



Artwork by James Babcock

TABLE 1: Comparison of Four Expeditions
(Cost exchange rates based on building trade wages)
(M means milions)

Expedition	May-flower	Mor-mons	Island One L5 Colony	Home-steading the Asteroids
Date	1620	1847	1990+	2000+
Number of People	103	1891	10000	23
Payload (tons)	180	3500	3.6M	50
Payload (tons) per person	1.8	2	360	2
Cost (1975 dollars	$6M	$15M	$96000M	$1M
Cost per pound (1975 dol.)	$15	$2	$13	$10
Cost in man-years per family	7.5	2.5	1500	6

I said nothing yet about the last two columns in my table. These represent two contrasting styles of space colonization, both taken from O'Neill's book, with some changes for which I am responsible. Column 3 comes from O'Neill's Chapter 8, which he entitles "The First New World," describing space colonization organized by the American government in the official NASA style. Column 4 comes from O'Neill's Chapter 11, with the title "Homesteading the Asteroids," in which

he describes space colonization done in the *Mayflower* style by a bunch of enthusiastic amateurs.

The cost of the "Island One" project is $96 billion. Many people, myself included, feel that $96 billion is a preposterously large amount of money to spend on any single enterprise. But still we have to take this number seriously. It was arrived at by a group of competent engineers and accountants familiar with the ways of the government and the aerospace industry. It is probably the most accurate of all the cost estimates that I have included in Table I. For this $96 billion you can buy a great deal of hardware. You can buy a complete floating city to house and support ten thousand people with all modern conveniences at the magic point L5, which is just as far from the Earth and from the Moon as these bodies are from each other. You can buy enough synthetic farmland to make a closed ecological system which supplies the colonists with food and water and air. You can buy a spaceborne factory in which the colonists manufacture solar power stations to transmit huge amounts of energy in the form of microwave beams to receivers on the Earth. All these things may one day come to pass. It may well be true, as O'Neill claims, that the investment of $96 billion will be repaid in twenty-four years out of the profits accruing from the sale of electricity. If the debt could be paid off in twenty-four years, that would be almost as quick as the *Mayflower* Planters could do it. But there is one inescapable difference between Island One and the *Mayflower*. The bottom row of Table I shows that the Island One colonist would have to work for 1500 years to pay his family's share of the costs. This means that Island One cannot by any stretch of the imagination be considered as a private adventure. It must inevitably be a government project, with bureaucratic management, with national prestige at stake, and with occupational health and safety regulations rigidly enforced. As soon as our government takes responsiblity for such a project, any serious risk of failure or of loss of life becomes politically unacceptable. The costs of Island One become high for the same reason that the costs of the Apollo expeditions were high. The government can afford to waste money but it cannot afford to be responsible for a disaster.

Can a family, bringing a total weight of only two tons per person, arrive at an asteroid, build themselves a home and a greenhouse, plant seeds and raise crops in the soil as they find it and survive?

After this brief visit to the superhygienic welfare state at Island One, let us go on to the last column of Table I. The last column describes O'Neill's vision of a group of young pioneers who save enough money to move out on their own from the L5 colony into the wilderness of the asteroid belt. They are going on a one-way trip at their own risk. The cost estimates here describe hopes rather than facts. Nobody can possibly know today whether it will be feasible for a group of twenty-three private people to equip such an expedition at a total cost of a million dollars. Anybody who is professionally qualified to estimate costs will say that this figure is absurdly low. I do not believe that it is absurdly low. It is no accident that the per capita cost estimates for the asteroid colony turn out to be similar to those of the *Mayflower*. This is the maximum level of costs at which the space beyond the Earth will give back to us the open frontier that we no longer possess on this planet.

According to the third and fourth columns of Table I, the cost per pound of the asteroid expedition is not significantly less than that of Island One. The big differences between the two expeditions lie in the number of people and in the weight carried per person. The feasibility of cheap space colonization in the style of the asteroid expedition depends upon one crucial question. Can a family, bringing a total weight of only two tons per person, arrive at an asteroid, build themselves a home and a greenhouse, plant seeds and raise crops in the soil as they find it, and survive? This is what the *Mayflower* and Mormon colonists did, and it is what the space colonists must do if they are to be truly free and independent.

No space probe has yet visited an asteroid. No scientific instruments have even been flown by an asteroid to give us a closer look at it. We are still as ignorant of the topography and chemistry of the asteroids as we were ignorant of the topography of Mars before the Mariner and Viking missions. Until some of the asteroids have been surveyed with instruments, it is pointless to try to foresee in detail the problems that colonists would face in making themselves at home there. Cost estimates for farming on an asteroid are meaningless until we know whether the soil is soft enough to be dug without using dynamite. Instead of speculating about the mechanics of space colonization in an unknown environment, I will only mention some institutional reasons why it may not be absurd to imagine a reduction in costs by a factor of 100,000 from the $96 billion of Island One to the $1 million of the asteroid colony. First we save a factor of four hundred by reducing the number of people from ten thousand to twenty-three. That leaves a factor of 250 still to be found. We may hope to save a factor of ten by accepting risks and hardships that no government would impose upon its employees, and another factor of five by eliminating trade union rules and bureaucratic management. The last factor of five will be harder to find. It might come from new technology, or more probably from salvaging and reusing equipment left over from earlier government projects.

Artwork by James Babcock

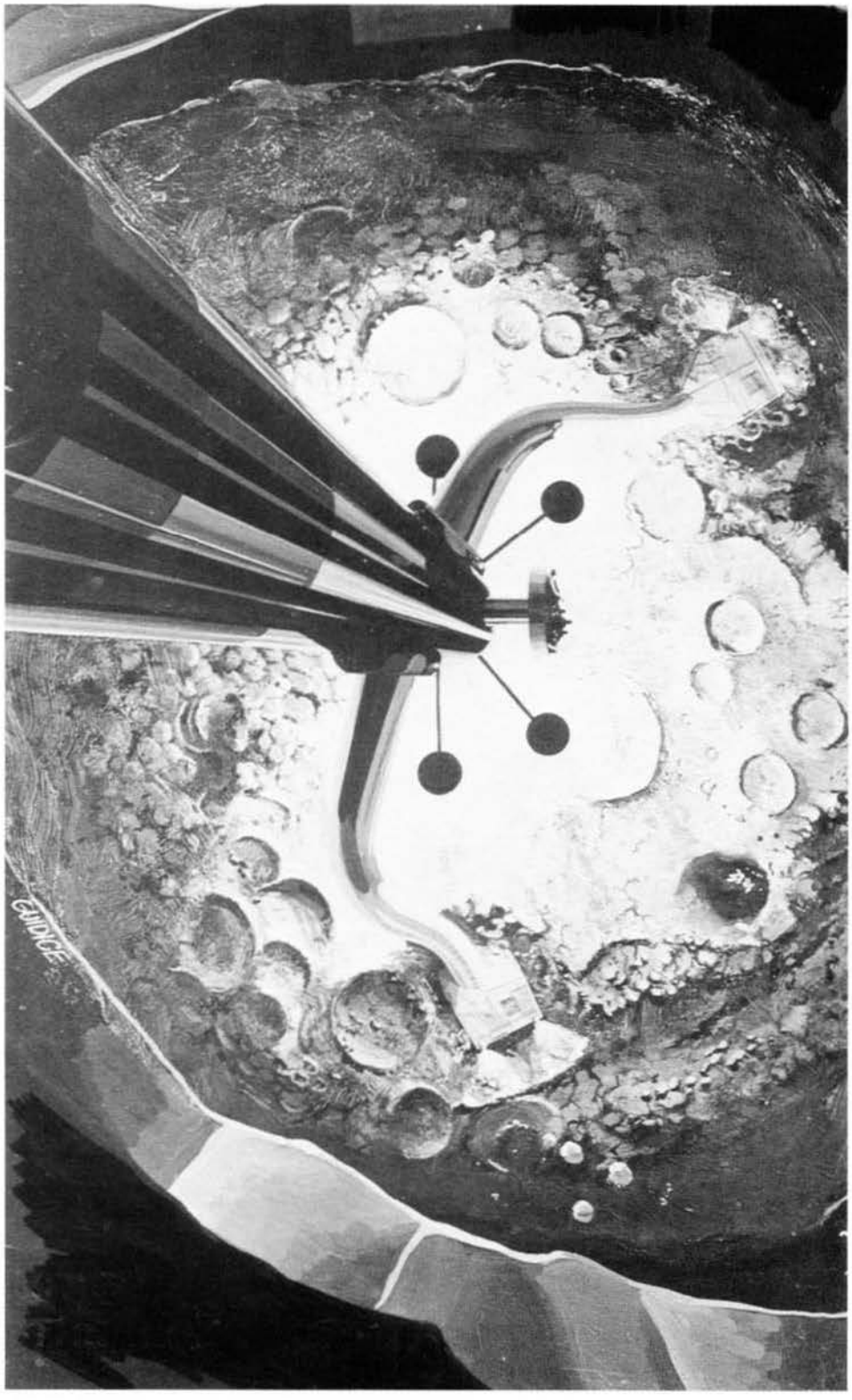
There are already today several hundred derelict spacecraft in orbit around the Earth, besides a number on the Moon, waiting for our asteroid pioneers to collect and refurbish them.

The Island One and the asteroid homesteading expeditions are extreme cases. I chose them to illustrate high and low estimates of the costs of colonization. The true costs, when colonization begins, will probably lie somewhere in between. In so difficult and long-range a venture, there is room for a mixture of styles. Governmental, industrial and private operations must all go forward, learning and borrowing from one another, before we shall find out how to establish colonies safely and cheaply. The private adventurers will need all the help they can get from governmental and commercial experience. In this connection, it is worth remembering that 128 years passed between the voyages of Columbus and the *Mayflower*. In those 128 years, the kings and queens and princes of Spain and Portugal, England and Holland, were building the shops and establishing the commercial infrastructure that would make the *Mayflower* possible.

O'Neill and I have a dream, that one day there will be a free expansion of small groups of private citizens all over the solar system and beyond. Perhaps it is an idle dream. It is a question of dollars and cents, as Bradford and Young well knew. We shall never find out what is possible until we try it.

The Environmental "Impact" of Not Mining the Asteroids

by Gregory L. Matloff



Utilization of material from Earth-approaching (Apollo and Amor) asteroids has been considered in plans for large space construction projects such as space habitats or solar power satellites.[1,2] Earth approach asteroids are short-lived, impacting Venus, Earth, or Moon in 10^7—10^8 years. Current estimates of total Amor and Apollo population are 1600 ± 800 for a diameter greater than 1 km, and about 10^5 asteroids are larger than 100 m.[1,3]

In addition, there must be many smaller bodies belonging to the Earth-approach families. On Aug. 10, 1972, an approximately 1,000 ton chunk of rock with an estimated diameter of 4 m grazed the Earth's atmosphere, reaching perigee about 60 km above Salt Lake City, Utah.[4] Because such a large object would not be completely decelerated by passage through the Earth's atmosphere,[5] the energy released by its impact upon the Earth's surface would have been equivalent to 20 kilotons of TNT—about the same as the Hiroshima/Nagasaki atom bombs. It has been estimated that such a collision should occur several times a century, with only 1% of the asteroids bouncing free,[4] as did the Salt Lake City meteor.

It is possible to generate an estimate of such impacts upon a global civilization if methods of retrieving or deflecting these objects are not pursued. For simplicity we will adopt a model for an eventual steady-state world population based upon some of the more optimistic initial projections of the "Club of Rome."[6] It will be assumed that the world population eventually levels off at 6 billion people, decentralizes, and covers most of the land (20% of the Earth's surface) with a uniform population density. The eventual population density of the Earth's land surface will therefore be about 60 people/km^2.

So far we have been lucky. Large meteorites have impacted in remote locations, at least in recent times. However, we can expect the impact of such a large meteoritic body to be similar to that of atomic bombs, at least in terms of immediate blast effects. The bomb that

destroyed Hiroshima completely devastated 11 km^2; the less-effective Nagasaki weapon completely burned out 4.7 km.^{2}.[7]

Thus, we can expect an average of 300 persons to be killed by each impact of an August 10, 1972 sized meteorite upon the land. It also seems reasonable to expect at least one such impact to occur each century. This is likely to be a very conservative estimate. Larger objects such as the 1908 Tunguska "meteorite" have not been considered.[8]

It is possible to compare this conservative estimate of 300 persons killed per century with possible environmental consequences of various human activities. According to a critique of the "Rasmussen" report on nuclear safety,[9] the risk to an individual of being killed by an accident in 100 light-water nuclear reactors is so low that in a century we can expect a population of 6 billion persons to suffer 120 deaths from such a system.

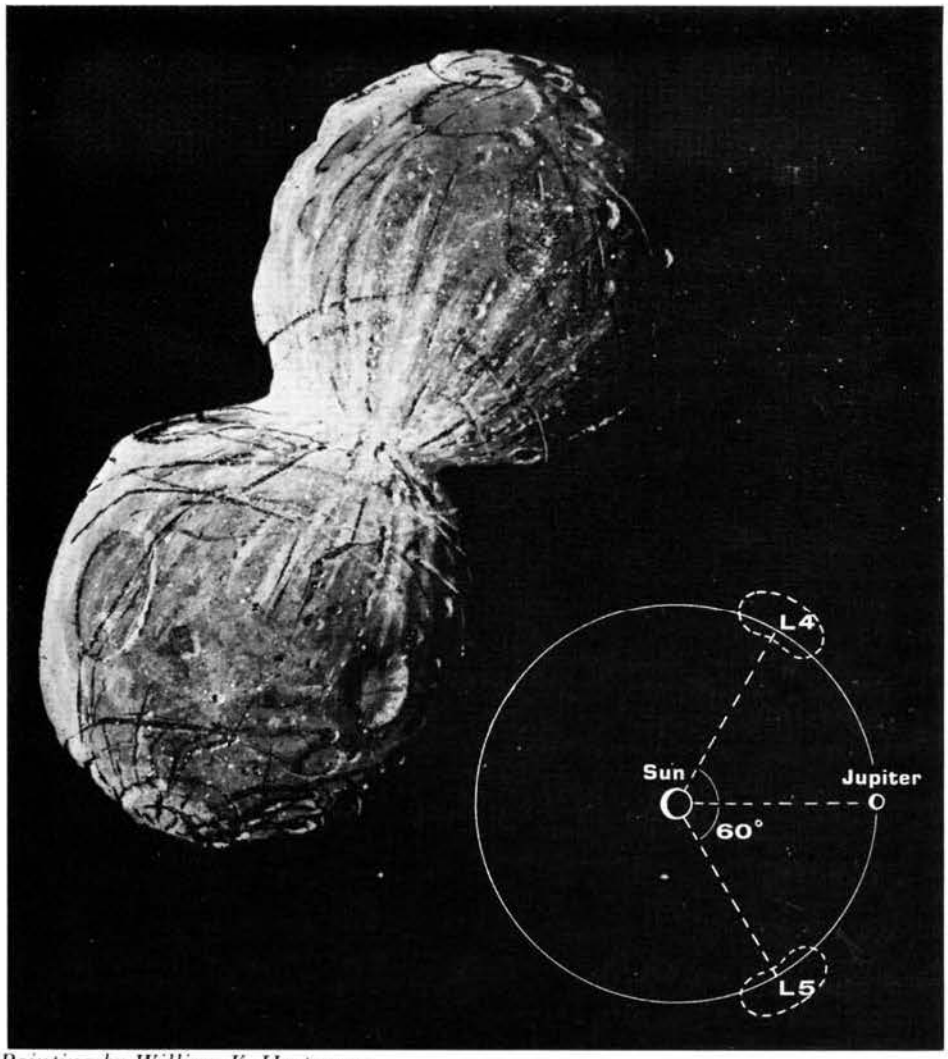
It seems, therefore, that the risk to a population by meteoritic impact is comparable in magnitude to the risk experienced in a nuclear-powered world. It is now nearly in our power to retrieve or deflect large meteorites before they enter the Earth's atmosphere. Since enormous sums of money are being invested in alternate energy systems to reduce the risk expected from a nuclear world, investment of the much smaller sum required to develop an asteroid retrieval system seems justified.

References and Notes

1. B.O'Leary, **Science,** 197, 363 (1977).
2. M.J. Gaffey and T.B. McCord, **Mercury**, 6, 1 (November/December 1977).
3. C.R. Chapman, J.G. Williams, and W.K. Hartmann, **Annual Review of Astronomy and Astrophysics**, 16, 33 (1978).
4. R.D. Rawcliffe, **Nature**, 247, 449 (1974); also see editorial in that issue of **Nature**.
5. F. Heide, **Meteorites** (Univ. of Chicago Press, Chicago, Ill., 1964).
6. D.H. Meadows, D.L. Meadows, J. Randers, and W.W. Behrens III, **The Limits to Growth** (Universe Books, New York, 1972).
7. See **Encyclopedia Britannica**, 15th edition, vol. 19, p. 1013 (1975).
8. B.G. Marsden, **Annual Review of Astronomy and Astrophysics**, 12, 1 (1974).
9. N.C. Rasmussen, "WASH-1400 (NUREG 75/014)," (Washington, D.C., Government Printing Office, Oct. 1975); A.M. Weinberg, **Bulletin of the Atomic Scientists,** 33, 54 (April, 1977).

L-5 Hosts Giant Peanut

by Carolyn Henson



Painting by William K. Hartmann

Asteroids cluster in the Jupiter/Sun L-4 and L-5 libration points.

Although astronomers have yet to locate so much as a whisp of dust at the Earth/Moon libration points, the Jupiter/Sun L-4 and L-5 libration points are crowded with huge asteroids. Often called the Trojan points because their asteroids are named after the heroes of the Trojan War, these libration points may someday become the center of major mining activities.

Last November, astronomers William K. Hartmann of Tucson's Planetary Science Institute and Dale P. Cruikshank of the University of Hawaii announced the discovery of the most unusual Trojan body of all: 624 Hektor. Shaped like a giant peanut 180 miles long by 90 miles across, it may have been formed when two asteroids bumped into each other at speeds slow enough to weld them together.

Wags have proposed renaming the peanut-shaped asteroid "Jimmy," after U.S. President and former peanut farmer Jimmy Carter. Perhaps a namesake asteroid out at L-5 would encourage Carter to put a little more money into NASA's flagging space efforts.

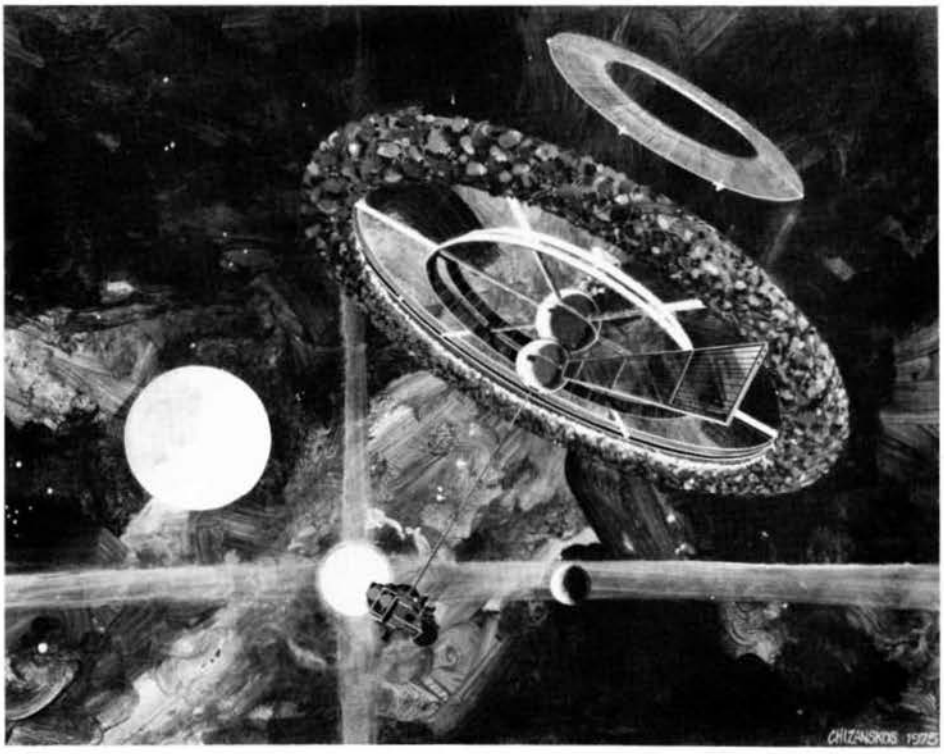
The Asteroids: Supply Stations for Elements

by Dr. Michael A. Pelizzari
Reprinted from **The Colonist,** *the Newsletter of the Texas L-5 Society.*

The Moon contains most of the elements that humans use in abundance. The ease of launching things from its surface will make the Moon an important source of these elements for building our first permanent outposts beyond Earth. But several elements are seen to be in very short supply there. As a result of terrestrial volcanic and hydrologic processes, trace elements often occur in concentrated deposits, making them accessible to miners. But similar deposits are unlikely to be found on the quiet, waterless Moon, making recovery of its trace elements difficult or impossible.

The elements carbon, hydrogen, chlorine, nitrogen, and possibly sulfur, among others, cannot be extracted from the Moon in sufficient quantitites to supply human needs. Must spacefarers import these elements from Earth? A "Stanford Torus" space colony would contain roughly a million tons of them, costing at least $15 billion to drag out of the Earth's "gravity well." Most of that cost is for carbon and for water, basic constituents of all life, and both completely missing from the Moon rocks sampled so far.

But hark! What light through yonder spectrophotometer breaks? 'Tis sunlight reflected from an asteroid which appeareth mightily like a carbonaceous chondrite of up to 5% carbon and 20% water—just what the Torus ordered! Hundreds of thousands of these mountain-sized objects orbit between Mars and Jupiter, while some forty of them (the so-called Apollo and Amor asteroids) have been observed on orbits much closer to Earth's. Although the origin of asteroids is still a mystery, their parent body or bodies have undergone more material differentiation than the Moon's surface. Valuable concentrations of trace elements can therefore be expected among the asteroids. If one with suitable composition and proximity can be discovered, it can be retrieved to provide some of the elements missing from the Moon. An electromagnetic mass driver (proposed to launch surface material into space) can be strapped onto an asteroid and used as a rocket engine, ejecting some of the asteroid's own mass to propel the rest into Earth orbit.



A "Stanford Torus" space colony which would contain about a million tons of the elements carbon, hydrogen, chlorine, nitrogen and others. While highly expensive to obtain from Earth, these elements could be obtained from asteroids.

Once the mass driver technology has been developed, retrieval cost of asteroidal mass could be as low as 20¢ per kg for an Earth-crossing asteroid 100 meters across. About 150,000 such objects are believed to exist, and it is simply a matter of "prospecting the skies" to find ones rich in the desired elements. Compositional information is obtained by reflectance spectrophotometry, a way of measuring how much light of each color is reflected by the observed object.

Besides carbon and water, the carbonaceous chondritic asteroids are likely to contain enough nitrogen and sulfur to satisfy human demand. This leaves chlorine as the only major element missing from the space resources likely to be tapped in the next 30 years. On a longer time scale, humans should be recovering even chlorine from outer space, perhaps by tapping the salty surface of Jupiter's most bizarre satellite, Io.

The estimated future demand for space resources is based on today's human consumption patterns, and does not take account of alternative consumption patterns peculiar to living in space, or the use of substitute materials as a means of striking a better balance between demand and supply. So, the reader is cautioned to take the numerical precision of this article with a grain of that Ionian salt!

Gas Entrained Solids— A Heat Transfer Fluid For Use In Space©

by

H. Keith Henson
Analog Precision, Inc.

K. Eric Drexler
Massachusetts Institute of Technology

Part II of a two-part article.

Even without zero gravity test results, we can say a *few* words and write some simple equations about the design of radiators using gas entrained solids.

Assuming that low density gas streams loaded with fine solids are well behaved, i.e. they stay well mixed and do not exhibit slug flow or other undesirable characteristics, then the design of a gas entrained solids radiator will take off from a determination of the maximum velocity of the gas/solid mix which will not wear away the radiator from the inside.

Wear decreases essentially to zero when the particle velocity perpendicular to the wall, V sin α, is less than a constant, K. K is a function of the physical properties of the particle and the wall.[5]

$$K = \frac{\pi^2}{2\sqrt{10}}\, y^{5/2}\, \frac{1}{\sqrt{d}} \left[\frac{1-q_1^2}{E_1} + \frac{1-q_2^2}{E_2} \right]$$

where

Y is the elastic limit of the wall material,

E_1 and E_2 are Young's modulus for the wall and particle,

q_1 and q_2 are Poisson's ratio for the wall and particle.

d is the effective density of the particle.

Note that particle *size* does not enter the equation, allowing the size to be determined by other characteristics or thermal properties. Particle shape does enter the equation, however. Sharp corners on the particles have the effect of increasing the effective density. The physical properties of the solids will be determined by what is cheaply available, and radiator walls must be built of something easy to fabricate, most likely steel or aluminum. Steel unrefined from asteroids would be just about ideal. Aluminum has a very low yield strength for most available alloys, but it can be anodized which creates a tightly adhering, high yield point layer of aluminum oxide on the surface.

For materials likely to be used, the computed and experimentally determined values of K are of the order of 1 meter per second. In straight tubes no wear would be expected for velocities up to at least 10 meters per second. Wear is likely to occur where the tubes change direction or join headers. Either the velocity could be reduced at these points, or replaceable wear plates installed. Taking 10 meters per second as the velocity of the heat transfer fluid as it flows around the radiator circuit, a number of other factors can be developed from the velocity and simple physical and geometric concepts.

An interesting side effect of the use of gas entrained solids is that the density can be adjusted by the simple expedient of saying "when" as the dust is being poured in. The optimal density ρ is determined by:

$$\rho = \frac{4aR}{Vc\Delta T}$$

where:

R is the radiation rate in kW/m^2

a is the aspect ratio (length to diameter) ratio of a radiator tube ($l/2r$)

V is the velocity through a radiator tube

c is the heat capacity $kWs/kg°c$ ($\simeq$1 for lunar dirt)

ΔT is the input minus the output temperature.

This funny looking expression comes from the contemplation of a single radiator tube of radius r and length l, Fig. D.

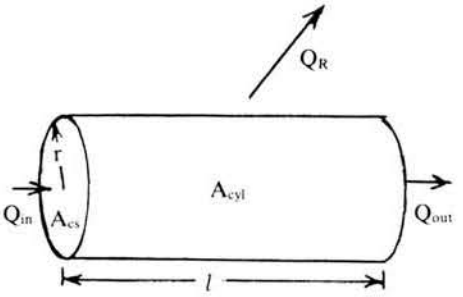


Fig. D.

The area of the tube and the radiation rate determine the heat flow Q_R.

$Q_R = A_{cyl} R$

The flow rate for heat in (out) is

$Q_{in(out)} = A_{cs} V \rho c T_{in(out)}$

where A_{cyl} is the area of the cylinder and A_{cs} is the cross section area of the tube.

Energy balance gives:

$Q_R = Q_{in} - Q_{out}$

or

$A_{cyl} R = A_{cs} V \rho c \Delta T$

solving for ρ,

$$\rho = \frac{4aR}{Vc\Delta T}$$

For an aspect ratio of 50, a radiation rate of 0.25 kw/m^2, velocity of 10 meters/second, and a ΔT of 20 degrees C, the density is 0.25 kg/m^3. This is about 1/4 of the density of air. If the gas (assume oxygen) to solid mass ratio were 10%, the pressure would be 2.5% of an atmosphere. The 10% figure is arbitrary. If zero gravity tests show less is necessary, we would use less.

While the density depends on the aspect ratio, the mass per unit of radiation does not. Mass per unit of radiation depends only on the length of the individual radiator tubes, i.e. many small tubes or a few large ones of the same length may be used in a given radiator without changing the mass.

If as above, $Vc\Delta T=200$, then m/R (in kg/kW) is equal to l (in meters)/200. This conclusion is in keeping with the logical arguments stated above. The 500 MW, one square kilometer radiator would use 1000 meter long tubes, and the heat transfer fluid would mass five kilograms per kilowatt.

There are limits on the range of the aspect ratio. Very short fat tubes would not allow the heat transfer fluid in the center of the tubes to come in contact with the wall resulting in poor heat transfer. As the tubes get longer and thinner, the necessary fluid density would approach that of solid rock!

A strange effect of adjustable density fluid (with a constant percentage of gas) is that the tube wall thickness turns out to be constant as the aspect ratio is varied. Changing the aspect ratio from 50 to 500 decreases the diameter of the example 1000 meter long tube from 10 to 1 meter. The fluid density needed for heat transfer would increase by a factor of 10 and, for the same ratio of gas to solids, the pressure would go up exactly enough to require the same wall thickness with the smaller diameter.

From the above, it can be seen that factors other than economy of wall material or fluid mass will determine the best tube aspect ratio. Low pumping losses and low leak rates and the efficient design of heat exchangers are some of these factors. The first two would be reduced by low aspect ratios and the attendent low pressure. High aspect ratios (resulting in high densities and high pressures) would make the heat exchangers less massive.* For the reference design, steel or aluminum stressed to 15,000 psi would be 1/8 mm or 0.005 inches thick. Meteoroid damage constraints are likely to require thicker walls.** If the walls were 0.008 inches thick (1/5 mm) the wall mass would be about 2kg/kW for aluminum or 4 kg/kW for steel.

Assuming lunar dirt or slag at $5 per kg, fabricated lunar aluminum at $25 per kg, and a factor of 2 for the headers, radiators operating at near the freezing point of water could be constructed for $150 per kW. Heat exchangers and fans might run another $100 per kW if they could also be constructed largely out of lunar materials. In this case, the reference design 500 MW waste heat radiator would cost $125 million. Using more optimistic numbers based on solar sail return of asteroid material, and advanced manufacturing techniques such as vapor phase fabrication, the cost might be brought down. Given filling for 50¢/kg, and steel for $1/kg, the radiator and headers would cost $13/kW. If the cost of fans, perhaps driven by small turbines, and heat exchangers roughly doubled this cost to $25/kW, the reference 500 MW radiator could be ordered from the Drexler/Henson radiator shop (motto, "No Job Too Large") for $12.5 million.

What are some of the implications these "dust filled radiators" might have on the early use of extraterrestrial resources?

To put these numbers into perspective, the investment in radiators per inhabitant of a space colony would vary from $20,000 to $2,000.

If engineering studies and zero gravity tests bear out these ideas, what are some of the implications for thermal cycle SPS designs and extra-terrestrial resource development?

One possibility, given the potential for lower temperatures (where water is liquid), is to use steam turbines. Gravity is normally used to sort out the liquid/gas phases in boilers and condensers. The boiler problem can be avoided by operation at supercritical temperatures and pressures. This might not be necessary as experimental boilers have been built where water was introduced at the top and steam removed from the bottom. The condenser may be a little trickier. We envision the steam turbine exhausting into a large drum. Tangential cold water sprays would provide the condensing surface and impart enough angular momentun to the condensate for it to swirl around the inside wall of the drum shaped condenser. Scoops placed in the flow would divert the condensate into pumps.

Condensate flow would be split, with some going to the solar boiler and the rest to a heat exchanger where the waste heat would be transferred to the gas entrained solids.

A steam SPS would look somewhat different from the current thermal SPS designs. Of course, the radiators would dominate the appearance. But more interesting might be the use of a large number of turbines, 1/4 GW or smaller. Because high heat fluxes can be carried by small mass flows of steam and boiler feed water, a few heat absorber cavities might supply steam for a number of turbo-generators spread out at intervals over the radiator surface area. Radiators and turbines might be located behind the sunlight collector area.

If there is any merit in these concepts, (and a considerable amount of engineering and space testing will be needed to tell) there are some very nice characteristics of steam turbines. One is that they present a low development risk. You could probably order them from General Electric today. Another is their high efficiency. At an easy to obtain 40%, their efficiency is about twice the theoretical maximum for silicon solar cells and roughly five times the eight percent now projected for a photovoltaic SPS. Of course, cost, not size is the determining factor, but counting the radiator area, a low temperature thermal SPS would have only 60% of the area of a photovoltaic SPS.

What are some of the implications these "dust filled radiators"might have on the early use of extraterrestrial resources? One possibility, if low cost asteroidal steel can be made available, would be to consider building SPSs at a space manufacturing facility which initially has no chemical processing at all.

For an intermediate step, with some SPS materials supplied from Earth, the rock dust part of the mass of a steam turbine SPS might be as much as 50%. The "do it from the ground" proponents make a good case that it's a long way from lunar rock to finished SPS parts. But, if all you need to make that rock useful for a large part of the mass of an SPS is a small vibratory ball mill, or even a screen, it is going to be hard on their consciences not to take a serious look at the early use of extraterrestrial resources.

We may be able to have our cake and eat it too. The solid fraction could be largely separated from the gas prior to entering the heat exchanger and the gas (which carries little heat) by-passed around the heat exchanger and reintroduced to the flow.

**Ways to find and fix leaks.

1) Put a lot of sized rubber balls in the radiator to plug leaks (a passive method).

2) Use molecular beam cameras mounted out on long struts to locate leaks. A 1 kg/day leak would be fairly easy to spot with an electron beam scanning of a fresh, active metal surface.

3) Build a tube crawler which could be directed manually or by computer to find and fix leaks by plugging them with a sheet metal screw or pop rivet.

REFERENCES

5. Bitter, J.G.A., "A Study of Erosion Phenomena," **Wear** 6 (1963), pg 169-190.

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NEWS BRIEFS

The Office of Technology Assessment (OTA), one of the U.S. Congress' fact-finding arms, will award $400,000 in contracts to study space technology applications. Remote sensing, communications and space processing manufacturing will be emphasized.

At the request of the Senate Commerce Committee, another OTA group is evaluating solar power satellites. This OTA study was first proposed by futurist Barbara Marx Hubbard in a Congressional resolution in 1978.

These two studies represent the first time the OTA has studied space activities. OTA was founded in 1973.

Between June 6 and August 20, special briefings for educators will be held three times each week at Johnson Space Center on Monday, Wednesday and Friday at 10 AM. Topics to be covered include lunar science, Landsat and the space shuttle. Free materials will be available at each session, which will last two hours. Attendance will be limited to the first 35 to register for each session. For more information call (713) 483-4241 or write to James Poindexter, Educational Progams Officer, Public services branch (AP4), NASA Johnson Space Center, Houston, TX 77058.

The space shuttle has been further delayed by main engine troubles, forcing NASA to reschedule at least four or five commercial payloads for expendable boosters. There is only a 50/50 chance that the first shuttle will be able to fly by June 1980.

On July 1, Thomas A. Mutch of Brown University was appointed NASA's Associate Administrator of Space Science. He succeeded Noel Hinners, who had resigned March 31.

Mutch has been leader of the Viking lander imaging team and a member of the Lunar Science Review Board. His responsibilities as Administrator for Space Science will include working with the Congresspeople who fund space sciences.

The U.S. House Appropriations Subcommittee on Military Construction has deleted the funds needed to install space shuttle launch facilities at Vandenberg Air Force Base. These launch facilities would enable the shuttle to reach polar orbits. These orbits are needed for spy and other military satellites as well as for Earth Resources satellites. If launched from Kennedy Space Center the shuttle would follow the heavily populated Eastern Seaboard, opening the possibility of a major disaster.

If this cut is upheld by the Senate, it will delay the first polar shuttle launch until at least 1984 and will force the government to buy $200 million worth of Titan launches to orbit already scheduled payloads. The Vandenberg shuttle facilities were budgeted for $78.2 million this year.

Solar power satellite boosters are rejoicing over the nomination of John Deutch for Undersecretary of Energy in the U.S. Dept. of Energy. Deutch, formerly an M.I.T. chemistry professor and a Rand Corp. and U.S. Dept. of Defense consultant, is well known as a progress-oriented, optimistic backer of energy R & D. Researchers say that Deutch is expected to give power satellites an even break.

Book Reviews

Reviewed by Chris Peterson
Reprinted from **Hubcap**, *the Newsletter of the New England L-5 Society.*

What do you say when the question comes up, "Why are you interested in this space stuff, anyway?" Most of us are pretty good at explaining why space utilization is a good idea economically but poor at explaining why it's important in other respects for the human race as a whole.

In a non-technical, even philosophical tone, J. Peter Vajk's **Doomsday Has Been Cancelled** examines the possibilities of space from many different perspectives. He explains why it's humane and socially desirable for a wealthy, highly developed nation to allocate some of its resources for space development rather than attempting to first fulfill the basic survival needs of every inhabitant of Earth. He also describes, in terms a layman can understand, how a space settlement program could reduce the threat of nuclear war, increase agricultural production, and improve the standard of living for everyone. The book focuses throughout on methods of continuously improving the human condition, and thus succeeds in demolishing the currently popular limits-to-growth and doomsday scenarios.

It is rare to find a scientist (here, a physicist) who can write so well. It is even rarer to find one who can write so effectively for an audience that has been traditionally hostile to the idea of space utilization. Although the book has wide-ranging appeal, a careful look reveals that Vajk seems to be addressing the concerns of those holding anti-technology, "small is beautiful," pro-decentralization perspectives ("soft-technologists," as they sometimes call themselves). He makes a persuasive case that space development is a cause these people should adopt. (He is right, of course. They, like us, are interested in improving the quality of human life. Vajk simply points out that utilization of space is the best way to achieve that goal.) And since his publisher, Peace Press, seems to cater to these interests (their list of publications includes such titles as **The Art of Zen Meditation, Chinese Healing Arts, Mysterious Herbs and Roots, Solar Cookery,** and **Survival Greenhouse**), many "soft-technologists" will be exposed to Vajk's book.

However, **Doomsday Has Been Cancelled** is not just for the "soft-technologists." Since this book is both highly idealistic and easy to read, it's the perfect book for those involved in the space movement to have handy when in need of inspiration or reinforcement. It is ideal for times like just before an L-5 meeting when you don't feel like venturing out in the rain or the night before testifying to a congressional committee on why they should include more funds for NASA in an austerity budget. Vajk's book will remind you just how important space utilization is—for all of us.

Doomsday Has Been Cancelled can be ordered from Peace Press, Inc., 3828 Willat Ave., Culver City, Ca., 90230, for $7.95 (plus 60¢ for shipping and handling).

Clarke's "Hyperfilaments" Fishing in Space?

by Ed Bas

Imagine a spool of fishing line, thin yet tough enough to slice your finger when you go to break it. Imagine fishing line thousands of times thinner, molecularly engineered for perfect, flawless crystalline arrangement, fishing line spun from metal and able to carry a charge. Interesting, but what's the point?

Toss the concept to a veteran science fiction writer like Arthur C. Clarke, and the idea turns into an avalanche.

Science fiction is the literature of ideas. You can read it for amusement and file it aside as you go back to reality and **Aviation Week and Space Technology.** But Clarke deserves better. For non-fans, Clarke co-authored **2001; a Space Odyssey** and, in 1948, **The Promise of Space.** He is one of the two or three most-honored science and science fiction writers, pioneering the concept of communication satellites before any existed.

When Clarke says something, it's good to stand up and listen.

In his latest novel, **The Fountains of Paradise,** Clarke begins with the concept of a hyperfilament. Manufactured in zero-gravity conditions of the first space colonies, the molecules-thick fiber is an engineer's dream: a perfect crystal structure is produced without gravity pushing itself in a search for randomness.

So what? Well, Clarke supposes, this metallic hyperfilament could carry an electrical charge, right? Suppose you had enough of such a filament to stretch from a place on the Earth up to a satellite anchored in geosynchronous Earth orbit? With near-unlimited electrical energy from Sunsats, you have the potential for the world's largest elevator—or bridge, as Clarke's main character prefers to call it. You have a relatively cheap, exhaustless Heavy Lift Launch Vehicle—and one probably more suited to the 21st century than the fat, inefficient chemical models which may be the only alternative to the space shuttle.

Clarke doesn't pretend that a snap of the fingers and handy-dandy spool of hyperfilament would do the trick. Molecules-thick or not, you're going to be dealing with an awful lot of mass in a "bridge" that long. Clarke has done some calculations to show that an anchor mass of the other end of this bridge would have to be bigger than any orbiting space station—it would have to be near asteroid-size.

For the Earth-end of the bridge, Clarke proposes a spot on the equator, preferably a high mountain with good weather.

The novel bears reading for more than its technical whiz-bang. But it also deserves careful reading by engineers, space scientists and potential space colonizers. Clarke seems to be saying, "Yes, of course we'll have space colonies. But now let's leap ahead and speculate on what will follow."

Another science fiction writer and visionary, Robert Heinlein, wrote about the moon's first mass-driver back in 1967, in **The Moon is a Harsh Mistress.** It was years before O'Neill and the MIT mass-driver models.

Both **Fountains** and **Mistress** grabbed hold of space economics and wrapped them in adventure stories. Both shout that space will belong to people only after they are capable of reaching it as easily as they pull onto the freeway to go home from work every night.

O'Neill Shows the Way

by Ken McCormick

When the Congressional Clearinghouse on the Future invited Dr. Gerard O'Neill to speak to Congressional staff persons on June 27, they were treated to an exposition of technology and even philosophy. O'Neill outlined a plan for "Near Term Uses of Non-Terrestrial Material for Human Benefit" citing various studies including one of his own projects. He also expressed thoughts on the eventual effects on society of *not* moving into space.

The tensions involved in the zero-sum game of "I win — you lose" are very much a part of our lives; they're a part of our lives every time we get in a gas line...

O'Neill's presentation dealt with work which has been completed during the last year on the use of lunar materials in the construction of solar power satellites. O'Neill called SPS the "present apparent largest single result that we could have from using this material," but he also explained that there could be other uses for lunar-derived construction materials, such as for very large communications antennae. Studies indicate that at least 5,000 to 15,000 tons per year of large objects could be needed in space for the next 30-year period, said O'Neill. An SPS program would require 120,000 tons per year.

The work he outlined was aimed at using existing technology to place in orbit one power satellite per year using the Space Shuttle as the only booster to low Earth orbit. This can only be done through the use of non-terrestrial materials (NTM), since an SPS would require 20 times the mass that the present shuttle program could launch in a year's time.

O'Neill referred to three NASA-sponsored studies which were completed this spring.

A study by General Dynamics/Convair established the overall economics of lunar materials use. The two conclusions of the study which O'Neill feels are most significant are that at least 90% of the mass of an SPS could be constructed from lunar materials, and that the use of lunar materials would reduce the overall cost of SPS without delaying the implementation of an SPS program. The study has been verified by an in-house review at Johnson Space Center.

An MIT study of the fabrication of large objects in space concluded that at least 96% of the mass of an SPS could be constructed from lunar materials. This also supports the conclusions of the aforementioned study.

A study by the Lunar and Planetary Science Institute in Houston examined the technology of the chemical processing of lunar soil and concludes that a processing plant in space would have a throughput of 100 times the mass of the plant itself per year. In other words, the plant would produce its own weight in usable elements every three to four days.

Dr. O'Neill then outlined one possible scenario for an NTM utilization project which he and his colleagues had worked out over the past year. In this "bootstrapping" approach, a 125-ton electromagnetic mass-driver, a chemical processing plant, and a plant for fabricating solar cells would be placed on the lunar surface by the shuttle, an orbital transfer vehicle, and a lunar lander derived from the Apollo program vehicle.

Since the solar cell array which would provide power for the mass driver would be ten times as massive as that device, lunar silicates would be used to gradually build up a 60 megawatt power array. The power array would then enable the mass driver to launch 300,000 tons per year of lunar materials. These 300,000 tons would provide about 100,000 tons of finished products in orbit.

Thus, through "bootstrapping" the lifting of 6,000 tons over a two- or three-year period from the Earth's surface would ultimately provide about 100,000 tons of construction material in space per year.

The funding level for this research has been at about one part in a million of the federal budget. "The reason that we can do so much with so little," said O'Neill, "is that basically we're not trying to push in any new science. There is nothing here as far out as, let's say, fusion power. This is straightforward engineering carried out in the way we've done it before."

Dr. O'Neill's elegant exposition seemed to have been wasted on many of the assembled staffers. One staffer asked if the people who had conducted the studies had remembered that a human work force would have to be maintained on the Moon. O'Neill assured him that they had remembered that and had included it in their calculations. Another person expressed the fear that the removal of lunar soil might have a grave effect on tidal or other forces. O'Neill pointed out that 300,000 tons is not a great amount of material when compared with the total mass of the Moon, but added that "lunar ecologists" such as himself see the asteroids as being the best long-term reserve.

If your fundamental belief is that humanity is evil, then the only way that you can deal with it is to hedge it around with a very rigid set of laws.

Near the end of the question-and-answer period, Dr. O'Neill expounded some philosophical underpinnings of his interest in space colonization. "Think of two alternative situations," he said. "One is that we stay within the very tight set of

bounds of our present planetary biosphere. We already see the effects of this confinement within the biosphere with the increase in population that's going on. There was a recent study, for example, indicating that the number of wars is now about four times as high as it was 50 or 75 years ago. The tensions involved in the zero-sum game of 'I win—you lose,' are very much a part of our lives; they're a part of our lives every time we get in a gas line...

"Such quasi-religious writers as Huxley and Zamiatin have looked into the question of the long-term implications of the steady-state society. They conclude that it must be highly rigid, and that rigidity must extend into the spiritual realm as well as the physical. I think we see that effect already around us now, because as soon as you begin to put tight bounds on something, then there will always be millions of people who will jump in and tell you how you have to run your life... This gives all of the people who'd really like to run other people's lives the license to legitimately do so, and that's what happens in a totalitarian state.

"So I think that the chances of maintaining ourselves within this finite biosphere and also extending personal freedom of choice are very, very small.

"On the other hand, . . . [the outcome of] the movement into space [would be] a very dispersed society . . .

"I think that you're dealing in the one case with a very great pressure toward rigidity, stagnation and monotony. In the other, you're opening up a very large number of paths for the development of small human movements — tens of thousands or even as few, perhaps, as 20 or 50. The *Mayflower* colonists were very small in number, but what they did was rather important. There could be many, many sets of *Mayflower* colonists in space, doing a wide variety of different things. Our ancestors were non-conformists. I think that there would be the freedom to non-conform in that new situation.

"To me that does approach a religious comparison, and certainly a spiritual one. If your fundamental belief is that humanity is evil, then the only way that you can deal with it is to hedge it around with a very rigid set of laws. If your fundamental belief is that if given a reasonable chance, ordinary people will develop in interesting ways and do interesting things, then you will want to give them the maximum opportunity to do so. That gets at the root of humanity, if not of religion."

It was not readily apparent how receptive legislative aides were to Dr. O'Neill's arguments.

Reading News

Aviation Week and Space Technology

Reprinted from **Hubcap**, *the Newsletter of the New England L-5 Society.*

One magazine that is a must for those interested in the latest developments in the space industry is **Aviation Week and Space Technology** (published by McGraw-Hill). **Aviation Week** regularly features a major section on space technology including news about the Soviet space program, the current Shuttle news (or its most recent troubles and delays!), other NASA developments, and recent activities in industry (as well as the current news in the aviation industry). Also, it features an "Aerospace Calendar" which lists all the major conferences on aviation and space developments.

Aviation Week not only reports scientific and engineering developments, but also reports on military, political and industrial activities. Since it is published weekly, the news covered is always current. In one week's issue there was, for example, an extensive article on "Shuttle Mission Control Training" reporting on the mission control center, various shuttle preparations, and even some of the latest astronaut training programs at Marshall Space Flight Center. It also included several brief articles on recent Soviet activity, payload insurance for the Shuttle, and Landsat news.

Most libraries subscribe to **Aviation Week** (if your local library does not, you might suggest they start a subscription). However, this magazine is very popular and doesn't remain in the library long.

If you are interested in subscribing, the rate is $33.00/yr. (with reduced rates for 2 or 3 year subscriptions). Write to:

Aviation Week and Space Technology
P.O. Box 503
Hightstown, N.J. 08520

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Over 150 pictures, several in full color, taken on the surface of Mars by the Viking 1 and 2 landers. $12.00

Watch Upon a Star

Describes the mission and activities of the Space Environment Services Center, which is charged with monitoring the Sun for events which affect life on Earth, and discusses the major physical and behavioral characteristics of this, Earth's own star.

Skylab EREP Investigations Summary

The scientific and technological achievements from the Skylab space program are numerous and include new knowledge of solar phenomena, of human capability for long-duration space flight and of the Earth through the sophisticated sensors that comprise the Earth Resources Experiment Package. This book summarizes the analytical results of 139 investigators who used EREP data in their study of problems in the areas of agriculture, range, and forestry; land use and cartography; geology and hydrology; and oceans and atmosphere. Contains many color photographs.

Princeton Space Manufacturing Conference Papers Available

The most up-to-date technical papers on the habitation and industrialization of space are available from AIAA, 1290 Ave. of the Americas, New York, NY 10019 for $1.75 each for AIAA members or $2.50 each for AIAA non-members. The available papers, which were presented at the May '79 Princeton Space Manufacturing Conference, are:

"Current Space Habitat Legal Developments," Edward R. Finch, Finch & Schaefler (79-1374)

"Carbon Dioxide Electrolysis Using a Ceramic Electrolyte," Richard J. Williams, Thomas Erstfeld, NASA-Johnson Space Center (79-1375)

"Excavation Costs for Lunar Materials," W. David Carrier, III, Lakeland, FL (79-1376)

"Electrostatic Separation of Lunar Soil," Ian Inculet, University of Western Ontario (79-1378)

"Chemical Processing of Lunar Materials," Robert D. Waldron, Lunar & Planetary Institute (79-1379)

"Electrochemistry of Lunar Rocks," Larry A. Haskin, Washington University (79-1380)

"Glass and Ceramics from Lunar Materials," John D. Mackenzie, Rex Claridge, UCLA (79-1381)

"Gas Entrained Solids—a Heat Transfer Fluid for Use in Space," H. Keith Henson, Tucson, Arizona, K. Eric Drexler, MIT (79-1382)

"Space Manufacturing and Public Policy Formulation," John Logsdon, The George Washington University (79-1383)

"Education for the Era of Space Industrialization," Kerry M. Joels, Smithsonian Institution (79-1384)

"Improving the Justification for Space Industrialization," John G. Barmby, Vienna, VA (79-1385)

"An Analysis of the Socio-Political Status of Efforts Toward the Development of Space Manufacturing Facilities," Robert D. McWilliams, University of Mississippi (79-1387)

"The Role of Public Interest Groups in Space Policy," Charles Chafer, Foundation for Public Affairs (79-1388)

"Financing Alternatives for Space Industrialization," J. Peter Vajk, Science Applications, Inc. (79-1389)

"The Economics of Strikes and Revolts During Early Space Colonization," Mark M. Hopkins, Rand Corporation (79-1395)

"Overview and Outline of Mass-Driver Two," Gerard K. O'Neill, William R. Snow, Princeton University (79-1396)

"Cryogenic Service Station for Mass-Driver Two," Kevin Fine, Henry Kolm, Peter Mongeau, Frederick Williams, MIT (79-1398)

"Linearization of Mass-Driver Geometry by Bucket Steering," Jonathan Leavitt, Princeton University (79-1399)

"Electromagnetic Propulsion," Henry Kolm, Kevin Fine, Peter Mongeau, Frederick Williams, MIT (79-1400)

"Duct-Burning Turbofan for an Earth-to-Orbit Vehicle Booster," James A. Martin, Shelby J. Morris, Jr., NASA-Langley Research Center (79-1405)

"Systems Integration in the Development of Controlled Ecological Life Support Systems," John L. Carden, Georgia Institute of Technology (79-1406)

"Waste Treatment Options for Use in Closed Systems," Michael L. Shuler, Cornell University (79-1409)

"Development of Space Manufacturing Systems Concepts Utilizing Lunar Resources," Edward H. Bock, General Dynamics/Convair (79-1411)

"Lunar Resources Utilization—An Economic Assessment," Robert Risley, General Dynamics/Convair (79-1412)

"New Methods of Solar to Radio Frequency Electromagnetic Energy Conversion," John W. Freeman, William Colson, Sedgwick Simons, Space Power Institute (79-1416)

"High Performance Solar Sails and Related Reflecting Devices," K. Eric Drexler, MIT (79-1418)

"Solar Power Satellite Beam Disturbance of the Ionosphere," James Drummond, Power Conversion Technology, Inc. (79-1422)

"Atmospheric Attenuation of Centimeter Microwaves," Warren Ziegler, Goddard Institute for Space Studies (79-1423)

"Guidance Trajectory and Capture of Lunar Materials," T.A. Heppenheimer, Center for Space Science (79-1424)

"Optical Scanning of Moving Payload Positions," Rainer Malzbender, Princeton University (79-1425)

"Light Pressure and Solar Wind Perturbations to Payload Trajectories," Brian P. Von Herzen, Princeton University (79-1426)

"Aesthetic Considerations in Bernal Sphere Design," Marjorie L. Stuart, Plandome, NY (79-1428)

"The Value of Anthropology for Space Settlements," Darlene Thomas, Lockhaven State College (79-1429)

"Consciousness Alteration in Space," B.J. Bluth, California State University (79-1430)

"Asteroid Prospecting and Retrieval," Brian T. O'Leary, Princeton University (79-1432)

"Low Thrust Alteration of Asteroidal Orbit," David Ross, Stanford University (79-1433)

"Collisional Orbital Change of Asteroidal Materials," Cliff Singer, Princeton Plasma Physics Laboratory (79-1434)

"The Search for Asteroids in the L-4 and L-5 Libration Points in the Earth-Sun System," R. Scott Dunbar, Princeton University (79-1437)

Please use the paper number (in parentheses) when ordering.

Announcements

The High Frontier Trading Post

A new feature of the **L-5 News** beginning in October, The High Frontier Trading Post will give L-5 members an opportunity to get in touch with one another. Each noncommercial member is entitled to one free ad per year, not exceeding 40 words in length. Extra or longer ads will be charged at a rate of $ .20 per word (or $4.30 per square inch). Please allow 3-4 months for your ad to appear. All ads will be subject to editorial review. Send your ad to:

The High Frontier Trading Post
The L-5 Society
1620 N. Park Ave.
Tucson, Az. 85719

FutureExpo

FutureExpo, described as "a vision of the future," is to be held on October 4-7, 1979 in the San Mateo Fairgrounds, San Mateo, California. People with new technology and innovations are urged to participate and present their ideas to the public. For more information contact:

The Griffin People Inc.
4300 Stevens Creek Blvd. 275
San Jose, CA 95129
(408) 247-7415

"Issues for Tomorrow"

This will be the theme of the southeastern regional conference of the World Future Society chapters to be held October 12 and 13 at Georgia State University's Urban Life Center in Atlanta, Georgia. Cosponsored by Futures Network and the L-5 Society, the conference will provide a forum for analysis and debate among policy makers and program implementers representing universities, professionals, government, business and industry. For more information, contact Estelle Greene, Conference Coordinator, Division of Public Service, Georgia State University, University Plaza, Atlanta, Georgia 30303. Telephone (404) 658-3466.

Lunar Electrochemistry Workshop

The Electrochemical Society and the Lunar and Planetary Institute are cosponsoring a three-day workshop devoted to the adaptation of techniques in electrochemistry to the processing of lunar materials on an industrial scale in space and on the Moon. The meeting is presently planned to be held September 12-14, 1979 at the Lunar and Planetary Institute. Participation by members of the lunar and

planetary community is encouraged. Many of the technical topics will be of relevance to the lunar sample research community. Your assistance is requested in bringing this workshop to the attention of colleagues in the fields of physical chemistry, chemical engineering and aerospace engineering. Electrochemical systems offer the possibility of obtaining industrial feedstocks from lunar and eventually asteroidal materials with minimum complexity and high reliability. For more information about this workshop contact either Dr. David R. Criswell (713/486-2152) or Dr. Robert D. Waldron (713/486-2158) at the Lunar Planetary Institute, 3303 NASA Road One, Houston, TX 77058.

International Aviation and Space Medicine Congress

The Organizing Committee of the XXVIIth International Congress of Aviation and Space Medicine, to be held October 8-12, 1979 at the Philippine Plaza Hotel, Manila, reports registrations are still being received from throughout the world. Organizing Committee Chairman Augusto E. Hocson, M.D., has announced that a large number of world leaders in Aviation and Space Medicine will be in attendance. Dr. Hocson added, "The Congress is open to paramedical personnel and other professionals involved with Aviation and Space Medicine, as well as physicians and surgeons specializing in the discipline. In addition, a highlight of the program of the 1979 Congress will be the participation of American astronauts and Russian cosmonauts."

Due to the limited amount of time prior to the opening of the Congress, the Organizing Committee is urging all persons planning on attending the Congress to immediately contact the Congress Secretariat, XXVIIth International Congress of Aviation and Space Medicine, P.O. Box 7675 Airmail Distribution Center, Domestic Airport Road 3120 Metro Manila, Philippines. Cable Address: AEROSPACE.

Moon Glass

A workshop entitled "Glass and Ceramics Industry in Space Based on Lunar Materials" was held at the Lunar and Planetary Institute on April 14-16. It was attended by representatives from the glass industry, university departments specializing in glass and ceramic products, automation and Spacelab research projects, and the Los Alamos Scientific Laboratory. They reviewed the many products that can be made from lunar materials and, in particular, analyzed the construction of a glass production facility on the Moon which could provide glass and ceramic inputs to a space power station. It was estimated that 40 people and 500 tons of equipment placed on the Moon could be used to create a glass plant with an output of 30,000 tons per year. Dr. John MacKenzie, University of California, Los Angeles and Dr. David Criswell, Lunar and Planetary Institute were co-chairmen.

A summary of the workshop can be obtained for $2.00 from:

The Lunar and Planetary Institute
3303 NASA Road One
Houston, TX 77058

Center to Study Life in Space

Many space enthusiasts feel that economic and social planning is lagging far behind the technological planning that may soon place large numbers of humans in space.

The Center for the Study of Human Communities in Space is being developed at Niagara University in an effort to overcome this planning lag. Under the direction of Professors Stewart Whitney and William MacDaniel, the Center is amassing a mailing list of interested scholars from a variety of social science fields as well as from the natural and physical sciences.

The goal of the Center is to develop a nucleus of informed scholars who will be prepared to meet the social planning needs of the national space program with expediency and efficiency.

The Center will be taking a major step toward achieving this goal next year when it sponsors a national conference aimed at identification of the numerous factors that may influence alternative approaches to establishing space settlements. The conference will also attempt to organize an efficient approach for incorporating these parameters into our future space planning efforts.

Those wishing to learn more about this effort may contact: Center for the Study of Human Communities in Space, Niagara University, NY 14109.

Space Solar Power Review

Volume 1, Number 1 of the **Space Solar Power Review** is to be published in the fall of 1979. It will be a quarterly journal dedicated to innovative research in the physical and social sciences on space deployed energy retrieval and transmission systems.

Space Solar Power Review will accept for review by referees manuscripts presenting previously unpublished information on any aspect of space solar energy research, measurement, development or application. These may take the form of scientific or engineering papers describing original studies (4000 to 6000 words), or shorter technical notes (600 to 2000 words), state-of-the-art reviews, and topical reports. News items and reviews of publications in this field are also accepted.

Manuscripts should be sent in quadruplicate to Dr. John W. Freeman, Editor-in-Chief, **Space Solar Power Review**, Rice University, P.O. Box 1892, Houston, Texas 77001 U.S.A. Only manuscripts in English can be accepted.

The **Space Solar Power Review** will be published on behalf of the Sunsat Energy Council by Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, New York 10523.

Science and Technology Hearings

Senator Howard W. Cannon (D-Nev.), Chairman of the Senate Committee on Commerce, Science, and Transportation, announced the availability of a Committee publication of hearings on the Office of Science and Technology Policy, held before the Subcommittee on Science, Technology, and Space on March 7 and 21, 1979.

These hearings were conducted to review implementation of the National Science and Technology Policy Act of 1976. The Act has four main objectives: to provide a statement on the National Science and Technology policy, to provide the President with scientific and technological advice, to provide a mechanism for management of Federal scientific and technological activities, and to provide a mechanism for developing a national science and technology agenda for Government, industry and the general public. The hearings assessed the effectiveness of the Office of Science and Technology Policy in carrying out these provisions. The hearings also examined the health of our national scientific community.

Persons interested in receiving a copy of the hearings should send a self-addressed

mailing label to the Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, United States Senate, Washington, D.C. 20510. Questions concerning the material should be directed to Steven Flajser or Stephen Merrill, Professional Staff Members, (202) 224-9351.

Voyager News Release Films

There are four 1979 NASA News Release 16 mm color films which can be purchased from:

Stock Film Laboratory Branch
Audiovisual Archives Division (GSA)
1411 S. Fern Street
Arlington, VA 22202
(Mr. Frank Stevens 703/557-1115)

The New Voyager films are:

NASA HQ 79-426 Voyager: Jupiter Encounters 1979
Approximately 8½ minutes, $86
A descriptive sound film about the objectives of the Voyager mission

NASA HQ 79-427 Jupiter Rotation
Approximately 2½ minutes, $26
A brief color film showing rotation of Jupiter as actually observed by Voyager I.

NASA HQ 79-428 Voyager I Encounter Film
Approximately 3 minutes, $30
A computer animation film depicting the flyby of Voyager I at Jupiter and its Galilean satellites.

NASA HQ 79-429 Jupiter's Atmospheric Dynamics
Approximately 2½ minutes, $26
A color film showing the atmospheric circulation observed on Jupiter by Voyager I during January 1979. Made from images of Jupiter taken every 10 hours of the same longitudinal region, including the Great Red Spot.

Orders must be received in writing and be accompanied by payment. The prices given above are only approximate. Exact prices can be obtained by phone. The cost estimates given are for projection prints, not master copies or negatives. Films are printed to order. It takes about seven days to fill an order.

Two photo suppliers have made lists of the Voyager pictures available: MMI Corporation, 2950 Wyman Parkway, Baltimore, MD 21211 and Photographic Illustration Co. (PIC) P.O. Box 6699 Burbank, CA 91510. Many other dealers are offering Voyager pictures (see recent issues of **Astronomy** and **Sky and Telescope**). The recent issue of **Astronomy** (May 1979) has several color reproductions of the pictures along with descriptive text of the mission. The Photo/Map Library at the Lunar and Planetary Institute (LPI) has sets of slides and copies of the films available for loan. Please contact Ron Weber, LPI Photo/Map Library, 713/486-2172 for information about their availability.

Encounter Dates

Voyager 2	Jupiter	July 9, 1979
Pioneer II	Saturn	September 1, 1979
Voyager 1	Saturn	November 12, 1980
Voyager 2	Saturn	August 27, 1981

Inside the L-5 Society

East Coast L-5 Conference a Success

Reprinted from **Frontiers**, *the newsletter of the Upstate Space Alliance.*

by Bruce Voris

The first east coast L-5 conference, hosted by the Space Futures Society, was held in Philadelphia on May 19 and 20. The conference started off with a screening of the Libra Colony, a film about the first space colony. Set in the near future (2000) the film presented a pessimistic outcome of the current oil crisis. By building solar power satellites from inexpensive lunar ore, the Libra Colony presented an ultimate solution to the energy problem.

Following the film, Dr. Brian Jones of Villanova University gave a talk on "Social Systems in Space Colonies." Dr. Jones first discussed some of the apparent causes for the present dehumanization of society and suggested that one of the main causes was the large size of bureaucracies inherent in a large modern society. He concluded that the smaller sizes of colonies in space would provide a much more conducive atmosphere for the development of stable communities. He was also encouraged by the possibility of examining the various types of social systems that could be set up on an experimental basis.

The evening dinner meeting provided an excellent opportunity for all the L-5 chapter members to get acquainted and to discuss their local chapter projects.

On Sunday morning, the conference continued with a "brainstorming" session focusing on key aspects of space development. Sources for funds that were mentioned included the Arab oil barons; instead of spending their money on gold plated Mercedes, they could invest in SPS. Other topics were tossed around. It turns out that the defense department is interested in O'Neill's mass-driver; they want to use it to accelerate artillary shells to mach 3. The second working mass-driver has almost been completed. This version of the mass-driver was designed to use superconducting magnets, operate in a vacuum, and achieve accelerations of 500 gs.

Ken McCormick gave an informal talk on how to influence Congress, and discussed some of the workings of that revered institution. He suggested that although a personal visit to a representative was not all that bad, one got the impression that congressmen at times do not like to be imposed upon by a lowly constituent. Ken said that writing a letter to the representative's office was nearly as effective as a personal visit and at times better, since a visit is a one-shot affair, that can leave a bad impression if not handled with care. He stressed that letters do count. For each letter that is received, it is assumed that there are at least 10-100 people in the district that feel the same way.

The conference ended with exchanges of addresses and commitments for better communications in the future.

Dr. Brian Jones of Villanova University. (Photo courtesy of David R. Jones, Jr.)

Errata

An incorrect address was listed for the Fresno L-5 Chapter in the May issue of the **L-5 News**. Mail correspondence should be sent to:

Chris Gudger
1440 E. Griffeth Way #215
Fresno, CA 93704

Mr. Gudger can be reached at (209) 225-0768 and the Fresno Chapter president, Edith L. Percy, can be reached at (209) 226-8480.

Virginia Tech News

The Virginia Tech Chapter L-5 Society has elected new officers for its third year as a university-recognized organization. Frank Quinto, an Aerospace and Ocean Engineering major was elected president for the upcoming year. Other officers include John Schneider, vice president; Martin Manley, secretary; and David Haig, treasurer.

The upcoming year will see the chapter continue as a clearinghouse of information for the university and surrounding communities, according to Quinto. A wider variety of slide lectures are planned for presentation to schools and interested groups along with other projects.

The Virginia Tech Chapter will be following through with its planned Space Week activities which include movies, lectures, displays, and the Deputy Project Manager of the Viking program, Cary Spitzer, speaking on the success of the Mars landing on its third anniversary.

Quinto summed up by saying it should be an interesting year for the chapter and the space program also. For more information, contact:

David R. Jones, Jr.
Information Officer, VA Tech L-5
P.O. Box 224
Boones Mill, VA 24065

Is Anybody Out There?

Elissa Wynn, co-chairperson of the Niagara Frontier L-5 Chapter, writes to remind members that if they have indicated that they want to be active locally, they will be included in the computer print-outs from the Society headquarters. If you want to be active but haven't let headquarters know, you risk being left out. Elissa comments, "There *must* be more of us in New York!"

Future Party '79

L-5 has been give a free suite at Future Party '79, a science fact/fiction convention to be held this Thanksgiving (Thursday Nov. 22 - Sunday Nov. 25, 1979) in Albany N.Y. Speakers will include L-5 board member Barbara Marx Hubbard, as well as Isaac Asimov, Jesco von Puttkamer (NASA), Hal Clement, Jacqueline Lichtenberg, Theodore Sturgeon and others.

The theme of our suite will be "Be a Space Activist." As well as an excellent chance to increase exposure of L-5 concepts and recruit members, it can also be a mini-con of Northeast groups. We will share ideas and experiences, catalogue regional resources and hopefully encourage the formation of new groups. Special emphasis will be on producing slide and other programs and displays, so if you have one to share, let us know and we will schedule it and list it on the con program. Anyone with experience in graphics and media would be most welcome to hold a workshop.

Attendance is limited to 700, so plan early. For more information and registration forms contact:

Niagara Frontier L-5 Society
40 Kings Trail
Williamsville, N.Y. 14221

Space Mapping/ Exploration Society

A new chapter of the L-5 Society, the Space Mapping/Exploration Society, has been formed in Sparta, Wisconsin. The next meeting is scheduled for Friday, September 7. For further information, contact the chapter president Dr. Wilfred E. Beaver, 418 E. Main St., Sparta, WI 54656.

Letters

Obviously we (the L-5 members) have a financial problem if the Legislative Information Service (LIS) is to be continually working with the Society. The $703.00 monthly budget proposed to continue this service is peanuts. If the L-5 Society cannot get its members to donate at least 150% of this monthly figure, then we should all look at ourselves as phonies, who may be part of an organization we really don't care about. All members should be asked to donate (tax-deductible or not) a grand total of $2.00 apiece for the remaining year. I am estimating here that the Society is now some 3500 strong. That's $7,000.00 in added donations or $1000.00 a month. No longer can those involved and interested in the successful transition to life in outer space sit back and read about legislation, ideas, and/or advances concerning space without an easy way to voice a respected opinion. Just look at what the government is proposing to do to NASA's budget over the next 5 years, a 1 billion dollar cut! Oh, excuse me, I forgot we need it for national defense, spelled bombs.

Ron DeMartini
San Francisco, CA

I sympathize with Eric Drexler's disappointment that the U.S. government "decided to develop a 'civilian' booster for purely symbolic reasons" instead of using "existing ICBM booster" (**L-5** "The Useful Pieces of Space," **L-5 News**, May, 1979). But I feel that Eisenhower's decision was for the best because it firmly divorced our space exploration from our military. While the decision cost us time, money, and prestige, it showed the world (and our own citizens) that our space efforts were not militarism in disguise. The Soviets do use the same boosters for ICBMs and space activity, and the world knows that their space program is controlled by their military.

Howard G. Beatman
New London, Conn.

H. Keith Henson's piece on "Space Forts" in the June **L-5 News** was a welcome examination of the very real trends in space weaponry. I have tried to explore the military's utilization of such weaponry in my novels, such as **Millennium**.

It has occurred to me that Solar Power Satellites may well be put into operation much sooner than even L-5 Society members expect, by the military of various nations, to provide the electrical power for satellite laser and/or particle beam weapon systems.

While most people tend automatically to reject the very idea of space warfare, out of esthetic or moral reasons, it is important to realize that the military purposes—not civil or humanitarian ideals—may very well be the spur to the development of SPS.

Ben Bova, Editor
Omni
New York, NY

The letter from James Oberg in your June, 1979 issue contains major factual errors which must be corrected. Jeff Phillips is no longer on our (SANE) staff, so I will try to answer on his behalf.

The argument in favor of a larger U.S. anti-satellite program rests on the assumption that the Soviet Union is rapidly building up its forces—that there is an "ASAT gap." Mr. Oberg, quoting from the **Air University Review**, contends that "predictions of the Soviet strategic forces were below the numbers that turned out to be actually deployed." In fact, the reverse is the case. We were told, for example, about the "missile gap" in 1959 and 1960 at a time when the Soviet Union had only a handful of intercontinental missiles and could not have possibly threatened American security. And today we are being told that Russia has achieved "strategic nuclear superiority" at a time when the United States has nearly 10,000 strategic warheads aimed at Russia's heartland. It's time we realize that there can be no gap or advantage to either side when each possesses the ability to obliterate the other many times over.

Both the United States and the Soviet Union are rushing insanely to load their satellites and space vehicles with military capability. The process is absurd, and extremely dangerous to the entire world. Rather than complaining about alleged Soviet advantage in this race, the L-5 Society should join with SANE and other public interest groups to halt this deadly competition and demand the peaceful use of outer space.

There is only one issue in the war in space controversy: the military use of space must be stopped.

David Coprtright
Executive Director, SANE
Washington, D.C.

You will be pleased to learn that, according to a news article in **Science** 4 May 1979 p. 484-486, the arch enemy of creative science William Proxmire (D-Wis) caused the U.S. Senate office building to have installed "magnetic" rodent repellers. Such units may have cost (us) $1195. each. The Senate building repellers were removed after the Environmental Protection Agency reported the results of 1½ years of tests to yield absolutely no results. The "repellers" were not effective at all, and produced no measureable effect on rats or instruments. The article does not say if the $1195 version was the one used in the Senate building, but the value of the parts in this "Nature Shield" model was $20, and the various differently manufactured versions are probably about the same in effectiveness and price.

Surely the honorable Proxmire gets the Golden Sheep award for this one!

John H. Mauldin
Canyon, Texas

I am a charter member of L-5 and a true believer in our future in space. With that established, I wish to say a few words in defense of Sen. Proxmire.

Sen. Proxmire does not oppose space exploration. Sen. Proxmire has said that he would support Satellite Solar Power Stations if the need and feasibility of such a project can be established.

Sen. Proxmire is very leery of any large project involving the U.S. Government and large corporations. Graft, boondoggles, blunders, and outrageous misrepresentation often are rife on such projects and Sen. Proxmire is not at all out-of-line for thinking that such could occur on a project of such magnitude as SSPS.

As long as space colonization is romanticized by it supporters, new supporters will be hard to find. The taxpayers will not approve of a program to spend hundreds of billions of dollars to provide an idyllic life for a few thousand people. Sen. Proxmire and other legislators recognize this.

To get the public to believe in space colonization, we have to show evidence of cost-effectiveness: the public is absolutely right in demanding a return on their investment. Sen. Proxmire is doing his job by watching such proposals closely.

If we can demonstrate solid merit in our program, Sen. Proxmire could be a valuable ally.

Charles S. Upp
La Quinta, CA

I am interested in correspondence with other L-5 members on space colonization. I have an idea for the Society that I got from another club that I joined. Why don't we print a small booklet of names and addresses of members interested in correspondence? This would greatly increase communication among members and would help to generate new ideas. It would also help local chapters.

Ted Apelt
3010 NW 36 St. Lt. A135
Miami, FL 33142

You can receive a list of people in your area who wish to be locally active at no charge from the L-5 Society—CH

Would the **L-5 News** be interested in doing some different kinds of membership surveys with me? What I have in mind is a loose or tear-out questionnaire in the **News** that could be folded and mailed, with the postage printed on it. I have two in mind: One as a sort of fluid shift simulation for the readers to peform and report on. Another, more detailed, would be a food opinion survey for prospective habitat colonists. Sample question: Since maximum efficiency dictates a closed loop life support system, how do you feel about recycling colonists into fertilizer when they die?

Absolutely unacceptable_____
Would rather not_____
Don't care, but not me_____
No big deal either way_____
Preferable_____
It's the only logical thing to do_____

By the way, I am a doctoral student in Nutrition at Florida State University, and I, too, look forward to the day when I can look back on the planet from a distance.

Karl E. Simanonok
Tallahassee, Florida

How about it readers? Would you like to see surveys like the above in the L-5 News? —JA

As it is usually suggested that a colony at L-5 would be an international community, and as the major stumbling block to building a colony is funding, I have a recommendation that may bring us a bit closer to both goals. At present, all the Astronauts and Mission Specialists for the Shuttle flights are either American or European. What if N.A.S.A. were to begin training Mission Specialists from Saudi Arabia and other OPEC nations? Not only would it strengthen American ties with these important oil exporting nations, but their interest in the Manned Space Program could lead to part of the funding necessary to make space colonization a reality.

William N. Ellis
Huron, Ohio

I am sorry to report that ISI is not selling stock in Michigan and that I could not obtain a prospectus from Mr. Basler. Perhaps you should print a list of the states where ISI is legally selling stock. I feel that now is the time to press SPS since we should be able to capitalize on oil decontrol and Three-Mile Island.

Michael Strong
Swartz Creek, MI

Washington State, OR, CA, AZ, TX, Wash DC, MD, NJ, NY, MA.