"Towards an Earth-Moon Economy - Developing Off-Planet Resources"

Moon Miners' Manifesto

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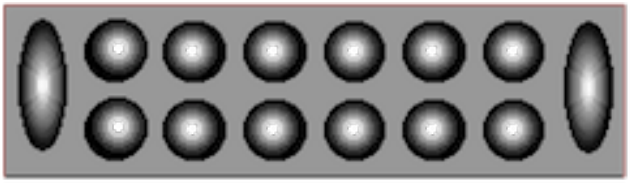
MMM Classic Themes

Lunar Arts & Crafts

APPAREL JEWELRY



Carved game boards (Oware/Mancala)

Bonsai Trees

MOONSPORTS TOY CHEST

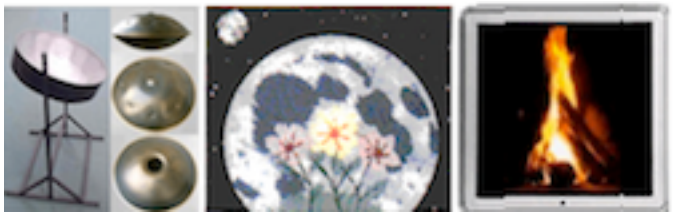
Raw glass dishware

sintered rusted moodust "Luna Cotta"

MOON MALL MOON-MUSIC

Hewn and carved basalt

water features



Pioneer HOLIDAYS

INDEX MMM THEMES: ARTS & CRAFTS
(Including Home Furnishings and Performing Arts)

FOREWORD:

Development of Lunar Arts & Crafts with minimal to zero reliance on imported media and materials will be essential to the Pioneers in their efforts to become truly "At Home" on the Moon. Every frontier is foreign and hostile until we learn how to express ourselves and meet our needs by creative use of local materials. Arts and Crafts have been an essential "interpretive" medium for peoples of all lands and times.

Homes adorned with indigenous Art and Crafts objects will "interpret" the hostile outdoors in a friendly way, resulting in pioneer pride in their surroundings which will be seen as far less hostile and unforgiving as a result.

At the same time, these arts and crafts, starting as "cottage industries." will become an important element in the lunar economy, both for adorning lunar interiors - and exteriors - and as a source of income through sales to tourists, and exports to Earth and elsewhere.

Artists love free and cheap materials, and their pursuits will be a part of pioneer recycling efforts.

From time immemorial, as humans settled new parts of Africa and then the continents beyond, development of new indigenous arts and crafts have played an important role in adaptation of new environments "as if they were our aboriginal territories."

In all these senses, the Arts & Crafts have played a strong and vital second to the development of new technologies that made adaptation to new frontiers easier. How could it be any different as we move to new continents across a new kind of sea?

What pioneer artists and craftsmen will do on the Moon, will be repeated on Mars with both similar and uniquely different results, and on other frontier worlds beyond.

Any "History" of a people that mentions only political, economic, social, technological, and military markers is woefully incomplete.

Enjoy, and we hope you will appreciate the possibilities of extending the Human "Out of Africa" epic to lands beyond all the more. Editor

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More kaleidoscopic articles of a similar kind will appear in future issues of MMM, #s 251 and beyond as we continue to explore the possibilities limited only by human talent and ingenuity. The Moon is a whole new world with every "limiting factor" a gateway to "unlimited possibilities." The Moon is a place for those who are convinced that "Yes, we can!" The limits of creativity in the blueprint of the human mind and soul are no more than temporary. This applies to our technological and engineering frontiers as well. Editor

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MMM #3 - March 1987

[The second in a series of articles on the need to pre-develop the "software" for a Lunar Civilization]

By Peter Kokh < kokhmmm@aol.com >

I remember as a young man too many years ago [1955] my first time in Hudson Bay Company (yes, the original Canadian Trading Co.) department store in Calgary Alberta. How impressed I was by the great variety of goods imported from all over the British Commonwealth -- an abundance of choices unsuspected by the shopper in Milwaukee's Gimbel's or Schuster's of that era. Things are different now. Today's shopper in any mall in America is confronted with a bewildering variety of offerings from all over the world. No one is limited to the goods and services made in his own city or town. Indeed, to be so limited, even in a great world class city like Chicago, New York, or Montreal, would be quite a come down.

How will it be for the shopper in a lunar or Martian mall the first few decades? The settlements will be small, though growing, and "**upports**" from Earth's gravity well will be prohibitively expensive. Almost certainly and without exception, they will be restricted to items, and even to mere components of items, that are both indispensable on the new worlds and as yet impossible to manufacture locally. For everything else, the settlers must be willing to make do with local resources and materials as best they can. No one ever said pioneering would be easy. The frontier may be exciting, but like frontiers from time immemorial, it will of necessity have its rough edges.

Will this mean one style, one color only of dishes, for example? One model, one color only for radios, stereos, and television sets? Only one style and color of sofa or chair or dresser? Uniform-like sameness in clothing? Unless we do some resourceful and ingenious planning now the answer might well be yes; and the consumers' paradise of Earth will have no counterpart in the consumers' pits on the Moon and Mars. There will simply be too few people to make more than the simplest variety of goods with no supplemental selection available through the Sears or any other mail order catalog.

Two approaches to this problem suggest themselves: one high tech, one low. For a small factory, changing styles, colors, shapes, etc. of whatever it makes in order to satisfy a variety of tastes usually involves expensive dies, molds, etc., and extensive downtime for setup changes. The challenge

here is to design production equipment which is set-up friendly so that limited runs can be made on a dial-a-style or insert-a-card basis with little loss in efficiency. Some modern production facilities on Earth are already being designed in the fashion. I am not privileged to work at one. In this way, just as one can dial a pretty pattern by the turn of a kaleidoscope, a consumer could order a unique set of dishes, for example, or a unique bolt of fabric. At the least, small production runs in each of many styles could be made without extra expense. Without this commitment to design Lunar or Martian factories to produce such kaleidoscopic product lines, life on the new worlds will be very drab.

[In the decades since this was written, computer aided manufacturing techniques have made all this possible.]

Remember, the people back on Earth won't care, and governments will give it bottommost priority. It's up to us to see that such possibilities come to realization.

The second approach which might work well on some lines of goods or be available as an alternative choice to the Lunar or Martian consumer is for the factory to produce (either exclusively or in addition to a regular line) a line of unfinished goods -- ready for the consumer or venturesome craftsmen to custom finish for him/herself or for resale. Some examples might be ready-to-glaze ceramic ware, ready-to-upholster furniture frames, and electronics chases sold without cabinets or with unfinished cabinetry, ready to dye, print, or otherwise embellish plain fabric bolts. Such secondary or co-manufacturing or custom craft finishing will likely become an important part of the frontier economy. And the person with crafting skills who can take a common ho-hum product and give it a unique and interesting touch might well enjoy the highest local prestige and social status. Those who do not have -- or refuse to develop -- the talent to custom finish purchased raw goods or who lack the income to pay someone else to put such touches on what they buy, might well be condemned to a home filled with the dull, boring, and commonplace.

Lunar and Martian society will greatly reflect this totally new set of rules in the consumer sport of acquiring a satisfying and personality-expressing collection of goods. On the Moon and Mars will dawn the new golden age of the artisan and craftsman. A "designer" item on these new worlds will mean something quite different from on Earth, for it will signify not a mass produced edition of a product designed by a famous name with high snob appeal, but rather a line of unfinished goods which have been designed to be easily, satisfyingly, interestingly, and kaleidoscopically finishable. And so there will be designer mediums, designer palettes, and designer frames and chases, etc. The designer who leaves the most scope for unique finishability will have the most honor.

Prospective settlers may be screened and accepted or rejected not only on the basis of their primary skill and occupation or profession but also on the basis of what they can contribute by their secondary talents, skills, hobbies, and avocations. If the new settlements are to avoid terminal blahs, the population will have to have a very high talent density in comparison with Earth.

We have already pointed out what we must seek to guarantee in the design of production equipment shipped to the Moon or Mars. We must also seek to guarantee a high priority for artistic and craft talent amongst the selection criteria for prospective settlers.

But we can make their lot far easier by doing some experimenting beforehand to develop new means of artistic expression limited to the materials and elements commonplace to the new worlds. Lead, gold, silver, copper, etc., are vanishingly present on the Moon, for example. Thus ceramics cannot use glazes based on the lead oxides; certain kinds of stained glass will not be producible; new forms of jewelry will have to be developed; new stains, and paints, and enamels formulated. Pre-clayed soils will be unavailable for ceramics and water will have to be worked into utterly dry Lunar soils to make fireable clay, etc. If those of use who are into arts and crafts here on Earth take Lunar restrictions as a starting point and through lots of work develop workable new crafts, that will give the colonists a head start. Without such SOFTWARE predevelopment, any Lunar civilization founded on hardware alone will surely suffer a fatal morale collapse. Can you help?

The above essay is online at: **http://www.asi.org/adb/06/09/03/02/003/moonmall.html**

MOON MUSIC

MOON MUSIC

By Peter Kokh kokhmmm@aol.com

A few weeks ago I took in an unusual concert: the Northern Illinois University (De Kalb) Steel Drum Band, largest and oldest in the country, was playing at the UWM Union (University of Wisconsin - Milwaukee). I went to get a fore taste of "Moon Music".

Humor me a bit with these assumptions. Musical instruments will not be "upported" ("up" the gravity well) from Earth to the Moon base or settlement -- too expensive. Yet the personnel or settlers will surely want to enliven their "evenings" with more than prerecorded music. This means fashioning musical instruments out of lunar materials in the base or colony shops.

What can they do without wood, without drum skins, without brass (which is a copper alloy: the Apollos' limited prospecting would indicate copper is no more than a trace element on the Moon)? Not being a fashioner of musical instruments by trade or hobby, I honestly don't know. But definitely, one option is the West Indies' steel drum, a cut-off 55 gallon drum whose bottom is then beat with a set of sledge hammers into a complex concave shape capable of sounding from 3 to 36 full, round, vibrant notes. Certainly assorted bells and cymbals,"saws", xylophones, and even marimbas with metal, glass, or ceramic resonator tubes will work. Music has been played on a keyed set of drinking glasses. And to be sure the electric guitar with a ceramic, composite or metal body.

But stringed instruments with wooden sound boxes or brass wind instruments? No way! Can something passable or even special in the way of stringed sound boxes and wind instruments or horns be made from such lunar materials as glass, glass composite, ceramics, steel, aluminum, etc.? Why don't you musically gifted tinkerers out there see what you can come up with. But indeed just the instruments above will make a great orchestra!

The NIU band includes an ensemble of thirty steel drums -- each tuned differently to complement each other in orchestral fashion. No amplification needed! While the band's repertoire includes the usual calypso, pan, and reggae tunes, it amply demonstrated the great versatility of these instruments by such numbers as Cool and the Gang's "Cherish", Dionne Warwick's "That's what friends are for", Bizet's "Carmen Overture", and the opening movement of Bach's "3rd Brandenburg Concerto". Unbelievable and very moving. The steel drum shows all the dominant lead power of the piano and yet can be as soft and delicate as the violin.

I doubt Moon settlers will ever miss Earth's traditional orchestral instruments. They will do quite well with what they can make from Lunar resources. The results will help contribute to a unique Lunar culture with a flavor all its own. Recordings of lunar renditions and original Lunar compositions will take their place on the shelves of Earth's music stores. Some Earth FM stations may even feature lunar music just as others feature soul, rock, jazz, classical, pop, and country. Some Earth groups may even catch the fever and "**downport**" instruments made on the Moon.

Wouldn't it be fun for our chapter to have a small "Lunar Ensemble" to play at our various public events? A steel drum or two, a xylophone, a marimba, some bells, cymbals, and castanets? Perhaps you know someone who isn't all that interested in man's future in space but would find it fun to be associated with us in this way. Working with associated groups like this would be one way for us to extend our influence beyond our core of dedicated activists. Sleep on it. **MMM** The above essay is online at:

www.asi.org/adb/06/09/03/02/003/moonmusic.html

PAPER CHASE

Paper Chase II

[The following article is abridged leaving out what is not applicable to Arts & Crafts]

[Third in a series of articles on the need to pre-develop the SOFTWARE of a Lunar Civilization]

By Peter Kokh kokhmmm@aol.com

On Earth with its vast atmosphere, oceans, and still extensive forests, we can arguably afford to withdraw such organic ingredients as hydrogen and carbon from the environmental cycle in the form of paper, plastics, etc. After all, Nature has been doing the same thing, "banking" these elements for geologically long times as coal, oil, and gas.

On the Moon the situation is quite different. Hydrogen and carbon do exist in amounts worth scavenging in the upper layers of Lunar soil, put there by the incessant solar wind. From Apollo samples we might expect every thou-sand tons of soil processed to yield (besides over 400 tons of oxygen) one ton of hydrogen, 230 lbs. of carbon, and even 164 lbs. of nitrogen (source: Stuart Ross Taylor. Planetary Science: A Lunar Perspective. Lunar and Planetary Institute, 1992, p 159). This is hardly abundance. Polar permashade fields certainly must be searched, but this scenario requires that the Moon's axis will not have shifted more than a degree or so in the past 3.5 billion years: a tall order. If any ices of water or carbon oxides are found there, they will certainly be needed to expand the biomass of the colony. Withdrawal and banking will still be quite out of the question. Hydrogen and carbon for non-biological uses will still be priced as "import elements."

[The above was written in 1987, eleven years before Lunar Prospector confirmed the existence of ice deposits at both poles. Yet the caution remains. Even billions of tons of hydrogen, carbon, and nitrogen (presuming that the ice contains carbon and nitrogen oxide ices as well, which one might expect if the source is comet impacts) -- even so much is not enough to support (a) lunar biosphere(s) if the population on the Moon grows to a considerable size. A conservative approach is still the best strategy, if we are not to stunt the growth of lunar development. -Ed.]

Paper is basically cellulose, a carbohydrate, half hydrogen & carbon, half oxygen. Its production in modern forms is very taxing on environmental air and water. While this may be a justifiable tradeoff on the bounteous Earth, the toxic burden of its production would soon overwhelm the very limited environments of Lunar (or in-space) settlements even if "waste papers" were recycled 100% (which would necessitate brainwashing all would-be settlers.) Luna City (and "New Tucson" at L5 as well) must be a paperless society. Throwaway addicts will argue this, of course, but then addiction has always been resistant to treatment.

[SNIP: Section on books and magazines (we predicted the Kindle reader!, boxes, labels, etc.]

Now a paperless society, Lunar or L5, is an enormous challenge and we had better begin preparing for it. A whole spectrum of alternatives must be developed and ready-to-go to address the diversified applications of paper in our civilization that have so insinuated themselves into our way of life as to almost define it.

Greeting cards and love notes: One can foresee a non-commercial and unpoliceable use of homemade art papers (such as are now well represented in art fairs) and vegetable inks for this purpose. Maybe the contradiction of personal mass produced greeting cards will at last give way to something that really does show individual effort. A possible black market item.

I am sure I have not covered it all, but I hope the idea is clear. Lunar culture in full bloom will be quite different from ours. But one can be assured that given preparation NOW, these differences will not be impoverishing. On the contrary, they should be refreshing and enriching. Certainly there will be lessons learned that may help Earth bound culture find its way to a somewhat less disharmonious relationship with our own host world. **MMM**

The above article is online at: **http://www.asi.org/adb/06/09/03/02/004/paperchase2.html**

MMM #9 - October 1987

MOONSPORTS

MOON SPORTS

[Much of what is said here will apply to the performing arts in 1/6th gravity]

By Peter Kokh

One can easily think of non-team sport activities that might work well on the Moon: gymnastics, swimming, road rallies, etc. But you can scratch sailboating, skydiving and other such outdoor sports.

Physical Constraints on Moon Sports

But what interests me here are the possibilities for spectator team sports. On the Moon, "sixth-weight" (1/6th G) will allow balls to bounce higher and travel farther (though, middoors, air resistance will have its customary effect) and at the same time reduce players' traction, maneuvering, and braking abilities, all while momentum remains quite "Earthlike."

Promising and not-so-promising models

Even with a greatly deadened basketball, for example, the game as we know it could not be played. The bounce, even if restrained in height, would be slower, and players could not dart about the court as easily, dribbling in slow motion. Baseball, Football, Soccer, and Hockey would be similarly affected. Rather than produce caricatures of familiar and beloved sports, it would be better to start fresh, and invent substitute sports from scratch.

Better candidates for adaptation, serving as a point of departure for "designer Moon Sports" might be handball or racquetball, or its exciting distant Basque relative, Jai Alai (pronounced Hi-a-lye) [a game like handball, played on a walled court with a hard ball, popular in Spain, Latin America and parts of the United States (Florida); pelota. The ball is caught and thrown with a curved wicker basket fastened to the arm - World Book], but without the parimutuel trappings. For lunar adaptation, the side walls could be thick one-way glass, allowing spectators to sit behind.

Table tennis or ping pong, bowling, and such small-field sports as lawn bowling, croquet, and miniature golf might work well enough, but these are not substitute for the big spectator sports. What can we do now, here on Earth, to help give future lunar settlers a head start in this direction?

We would need to simulate lunar conditions. An awkward and certainly unworkable "game plan" would be to do so by tying carefully metered helium balloons to athletes' arms, legs, and torsos to simulate reduced weight and traction along with undiminished momentum. A much better idea is computer simulation, in which all the effects of sixthweight on traction, acceleration, speed, bounce, trajectory, braking, etc. could be taken into account. Gaming rules would certainly be affected. Side walls could be as important as the playing field or court customarily considered. All the of a proposed game must be varied: number of players, type of ball and/or other equipment, dimensions, rules etc. until a computer simulation resulted that promised exciting, ever interesting and gripping play.

On Earth, we have already taken preexisting games as points of departure and created new sports which bear only a curious relationship to their design ancestors, Thus, English Rugby is a distant

precursor of American Football and English Cricket of American Baseball. On a hunch, I'd recommend any would-be Lunar contact sport designer would do well to consider Rugby for inspiration.
Income-generating sports telecasts

The goal is a number of sports well-enough designed not only physically but in game play to excite spectators and keep them coming back, resulting not only in whole new sections in the Guinness Book of Records, but in heightened Tourist Lure! The "Saturday Wide World of Sports" TV show would have to change to "Wide **Worlds** of Sports" as telecasts of Lunar sporting events to Earth become commonplace and finally bring home to "Joe 6-Pack" in his Earthbound armchair that, yes, the "world" has expanded to include new turf.

Such telecasts could be a source of considerable income to the settlements, adding in both royalties and purchases of commercial time for sponsors. And here and there will be the young Earthling who will crave to try these sixthweight sports, which he/she can now only passively watch, kindling in them the first ardors of a yearning to join the settlers someday. **MMM**

MMM #11 - December 1987

SPACE OASES & LUNAR CULTURE

[SNIP] What may be perfectly obvious to us, doesn't necessarily suggest itself to others: namely, that in the early decades, the availability of volatile-rich ores from asteroids and other sources cheaper to access than upports from Earth, will be at best sporadic. As a result, pioneers in free space oases will find themselves in much the same straights as hardy lunar settlers. Unless they are fantastically prosperous and can afford heavy dependence on Earth-sourced materials, they too must build their cultures largely on the possibilities inherent in volatile-poor lunar ores. Lunar cultures will be the rule.

Thus, in the early decades, space colonists too will be forced to give up a way of life based on the causal use of paper, wood, plastics and the whole host of addictive synthetics based on hydrogen, carbon, and nitrogen so very abundant on Earth. This will color their whole way of life with its implications for building products, household furnishings and other domestic wares, clothing, information media, sporting goods, toys, arts and crafts etc. [snip]

MMM #13 - March 1988

APPAREL

EVERYDAY AND OCCASIONAL [made on Luna] CLOTHING FOR THE EARLY SETTLEMENT

By Peter Kokh

PROHIBITIVE COST of imported clothing: the need to maximize "lunar content"

When token humans first return to the Moon, their clothing will come with them and be resupplied from down-the-well as necessary. Once the limits of the beachhead are burst and settlement begins in earnest, it will become necessary of success to cut avoidable upports to the bone. What about clothing?

The most important consideration is fabric content. Only fiberglass with currently limited apparel applications is totally Moon-sourceable. Baring (and/or until) discoveries of and access to sources of supposedly Moon-exotic elements such as hydrogen (H), carbon (C), and nitrogen (N), fabrics which contain the smallest proportion of these in comparison to Moon-sourced oxygen (O) will be the cheapest to manufacture on location.

Most synthetics besides rayon consist of H, C, N, and even chlorine (Cl) almost exclusively, and there will be no advantage to making them on the Moon. Indeed, considering both the amount and nature of the waste byproducts of their manufacture, such fabrics are most cheaply made and imported from the source worlds of these elements: Earth at first, then possibly the Martian moon Phobos, or an Earth-crossing or Earth-approaching carbonaceous asteroid. Without growth-defeating subsidies, such fabrics as nylon, Orlon, Dacron, acrylic, polyester, etc. will be quite expensive compared with Moon-grown cotton, especially since they are not biodegradable or recyclable (except through incineration with attendant nightmares for small biospheres) and represent possibly permanent "banking" of these precious elements - permanent withdrawal from the mini-biosphere. The early settlement might well put such synthetics on the contraband list. Does the frontier begin to look "rough?"
COTTON to the rescue?

Fortunately, cotton is still the most versatile and comfortable fabric known to man. It can be made into many forms: broadcloth for shirts, muslin and percale for bedding, flannel for shirts and nightwear, velour and velvet and chintz for upholstery, terry for towels - the list goes on. before you breathe too deep a sigh of relief, however, be aware that some of our modern processing techniques for cotton will probably be taboo on the Moon. Mercerizing which treats cotton yarns or fabrics with caustic alkali under tension, in order to increase its strength,,luster, and affinity for dyes is an example. It renders cotton less biodegradable. Modern colorfast dyes are derivatives of coal tar and both in themselves and in the application process, "contaminate" the fiber further. Not all bleaches are ecology friendly. Where does this leave us?

Taking Clues from Earlier Frontiers

Settler resourcefulness with cotton will not need to start from scratch. We need only to turn back the clock to an earlier age for a whole litany of ways to treat and embellish cotton wear. To start with the seed fiber itself, not all strains are the same natural white. Egyptian cotton is rather beige or tan in hue. By including several strains of cotton, a natural cotton-palette of shades could serve as a starting point. Might genetic engineering come up with cotton pre-dyed with such natural colorants as indigo (denim blue), henna (red-orange), chlorophyll (green), etc.? This would be a useful and ecologically responsible line of experimentation. If we began experiments now, we could conceivably make a lot of money in the "green" market among the growing numbers of environmentally aware consumers.

Where bleaching is desirable, gentle bleaches such as prolonged exposure to sunlight, or more probably, (with less side-effects injurious to the fiber) hydrogen peroxide (H_2O_2), a cousin of water. Vat dying of the yarn or finished fabric or item can be with done with biodegradable indigo, henna, and other naturally occurring vegetable pigments. Lessened exposure to sunlight, and more extensive use of sonic laundering methods might prolong the half-life of these gentle colorants

At home, settlers can take bolts of material or finished items and tie-dye them, use biodegradable "paints", etc. Batiking, which works best with unsewn yard goods, is another possibility.

Premium on Efficient Fabric Use

Since lunar cotton still represents a 50% investment in "foreign" hydrogen and carbon, there will be strong incentive to use it efficiently. I am reminded of the yearly contest run by POPULAR SCIENCE for designs in plywood, for which the most important criterion is most efficient use of the whole sheet or half-sheet as the case may be. Patterns to be featured in books for the lunar home sewer will likewise take care to use the whole of the required yardage. This may mean "fuller" garments or accompanying accessories made of the same piece: ensembles. Any scraps can be used for doll-making, patch-work quilts, or oval-braided and other rag throw rugs. These latter items will also be the next stop for worn-out clothing items. Beyond that, if care has been taken in processing, will be full biological recycling.

Role of Early Settlement Enterprise

Instead of home-dying and home-sewing, yard goods stores will profitably include do-it-yourself dying and sewing areas with libraries of pattern and how-to books and hovering adepts. Because of the small size of the market, pre-dyed goods are likely to be available only in staple solid shades. Variety will be introduced by the end user or by entrepreneurs willing to produce limited runs of prints, etc., on speculation or on commission.

Pre-sewn finished items in common sizes and colors will be available as something to fall back on for those too busy or disinclined to fashion their own wardrobes. The penalty will be a somewhat uniform look. For everyday apparel, this may be tolerable for most. But for some some of the time, and a for few all of the time, personalizing embellishment of standard issue will be important.

Getting Fancy -- Adornments

The least expensive personalizations and perhaps the most versatile will employ all lunar materials: self-colored (metal oxide) fiberglass fabrics for appliqués, shoulder wraps, and other add-on, wear-over items; medieval and cheerfully anachronistic chain-mail wear-overs for formal occasions; American Indian style glass-bead belts, pocket flaps, cuffs, collars, etc.; macrame shawls using glass and metal beads; metal and glass composite (non-brittle) sequins; buttons of colored and marbled glass, cast basalt, cut and drilled breccia rock, metal, dried and carved peach pits (a lost Chinese art); tassels of colored yarn, or even shorn human hair; etc., etc. You begin to see that settler resourcefulness will be much aided by a complete reference library to ethnic and folk methods of the pre-modern era. The effect will be a greater library of anything-goes than we are used to in modern society where our seemingly endless variety operates within subtle fashion dictates.

Inter-Settlement Trade & Specializations

Outlying settlements (road stations, specialized mines, etc.) may specialize in particular processes or fashions, developing them to a salable level. At any rate, Luna City will become the Paris of Space. For its wears will be the cheapest to import or copy for those living in Low-Earth-Orbit (LEO) or other Cislunar free space settlements.

Next to the Skin

Those not used to cotton underwear will have to forego silk and nylon, etc. If it is decided not to import elastic or Spandex banding, multi-snap boxer-style waistbands may be needed. Bras may be hard to come by, nylon hosiery as well. But there will be ample other means of accentuating and highlighting sexual differences.

Beyond Cotton?

Beyond cotton? Linen, better used for bedding, tablecloths and upholstery, is also a pure vegetable fiber and is cost-competitive with cotton. Rope making fibers fit the same class. If wool is to be introduced eventually, cavies (Peruvian Guinea Pigs) and goats are alternate sources. These may be introduced primarily for meat and dairy products and the availability may be restricted enough to add a market premium on such wool, over and above what is warranted by import-content.

- A “pressure valve” lottery and other means of entry for imported exotic fabrics and special apparel items
- A settlement-run lottery might award vouchers for rationed imported fabrics in lieu of cash prizes for a healthy outlet to the frustrations of usual choice restrictions.
- Incoming settlers fresh from Earth could wear borrowed costumes for the journey, that upon arrival would go to theater wardrobes and masquerade rental stores, it being bad taste to wear such terrestrial items except on very special occasions.

The Moon: an interesting place to live, don't you think? -- Peter Kokh

[in MMM #15, May 1988, NSS Chapters Coordinator Aleta Jackson sends her constructive comments. Look for “THREADS” reprinted below.]

MMM #15 - May 1988

THREADS

More on Made-on-Luna Frontier Apparel

(See “Apparel” in MMM #13 [above]

By Aleta Jackson, NSS Chapters Administrator

I am a long-time SCAer: Society for Creative Anachronism. [1] Part of the joy of being anachronist is researching period clothing. I have learned to card, spin, dye and weave my own cloth. I have studied the fabrics and dyes used in various cultures and continents. If you can get a bunch of

SCA people together with your chapter for a weekend brain-storm about Lunar clothes, you will probably come up with some really dynamite ideas.

i think you're wrong about silk; silk last a long time, masses very little, and has many applications, even after it's starting to rot, which won't happen unless you severely mistreat it. It won't evaporate like polyester, it's strong and elastic even under extreme temperatures, and is able to tolerate tremendous punishment. I bet someone could make a bundle of money importing silk clothing, and eventually a silkworm farm might be a great industry in one part of the colony. [2] mulberries (the leaves form the diet for silkworms) make tasty pies, too.

And don't forget ramie, a vegetable fiber. Combined with rayon (which was developed to replace silk during WWW II and which I love almost as much a silk) it makes a lovely fabric. Ramie combined with linen (from flax), cotton and silk produces fabrics that take dyes very well. It also helps "wick" sweat from the body into the fabric and so promotes evaporative cooling.

Another vegetable fiber that combines well with cotton is agave. I bet you can find all kinds of uses for agave, which thrives in desert conditions. I have an agave bedspread that has been through the wars and is as soft and supple and lovely as new. I grew up in Arizona, where we grow both agave and cotton. Cotton takes a bunch of water. Agave is a water conserver, produces a good beverage, flowers, and fiber.

You can get some really neat dyes -- deep, rich, long-lasting colors -- from minerals mixed with everyday biodegradable chemicals such as urine, which is useful for all sorts of things. [3] I no longer have my wonderful dyeing books or I'd be able to write the formulae here, but check your local spinning guild [or the arts and crafts section in your local library]; I bet they'd be really interested in lunar clothing possibilities and they might have good suggestions.

Drawstrings have worked nicely for centuries, and I still make a lot of my pants with them. Skirts, too. Comfortable bras can be made by combining drawstrings and cleverly woven cloth which has been cut to give in the same "give" of elastic. Sometimes better and longer-lasting that elastic, it's what was done in the old days.

Unless, they're redesigned, what you will probably have to give up is zippers and return to laces and gussets, which aren't made from valuable metal or easily degraded plastic.

About bleach. Dilute lemon juice and sunlight work wonders. That's how I bleach my find handwoven linen Rumanian blouses and dresses. Which brings up a question you may have answered but I've missed: whatcha gonna do for soap? [4]

Sincerely, Aleta Jackson

Editor's notes:

[1] The SCA adds much color to Science Fiction Conventions.

[2] Silk requires extremely labor-intensive unraveling of zillions of silkworm cocoons. If machines can be invented to do this task well, we may have an enterprise proposition.

[3] A Junior exhibit in our recent SW Wisconsin High School Science Fair showed good cotton-dyeing abilities for coffee, tea, onion skins and beats; and poor results with spinach and carrots.

[4] ? We'll have to look into that one. **MMM**

MMM #16 - June 1988

Frontiers Have Rough Edges

Commentary by Peter Kokh

A major theme running through many of the articles in the MANIFESTO has been this dual one:

- Settlers can become largely self-sufficient on a volatile-poor world like the Moon and in free-space oases initially dependent on Moon-sourced goods and raw materials
- This effort will involve widespread substitutions (and doing without, when substitutions can't be found) that will take some getting used to, as the pioneers wean themselves from an Earth-learned addiction to sophisticated organic materials so easily produced on the home world only to be casually used, often just once, sometimes not at all, and then just as casually thrown away. The

transplantation of human society from Planet 3A to Planet 3B will involve definite sacrifices for the early trailblazers.

There may be many who, misguided by ill-thought-out science-fiction scenarios, look forward to life on the space frontier expecting that there, they will find the latest, the most advanced, the most sophisticated possible technological culture. They would best be jolted out of such illusions and advised to stay home. For to tell the truth, for some decades after the opening of out-settlement, it will be on Earth that the highest, the most advanced, the most sophisticated material civilization will exist, at least in the more fortunate areas. In contrast, space frontier homestead scenes will seem insultingly drab, tedious, and harsh.

Even so, 17th and 18th Century Europeans who wanted the material best and most genteel that life had to offer remained in Europe. Even so, 19th Century East Coast Americans who wanted as comfortable and materially gratifying a life as possible remained in Philadelphia, Boston, and Charleston. The frontier is for those for whom other things are far more important than creature comforts and sophistication. It was so on the American and Australian frontiers, and will be on the frontiers of the future. Hardship is the stuff frontiers are made of!

Life in the new “outer Siberias” will be simpler, yes, simpler, even if forever dependent on high technology. But it will also be a more authentic and honest life with more attention given to things that count. There will be religiously rigorous recycling and careful accounting for everything. The premium on art, craft, creativity, and ingenuity will be high and the opportunity to indulge in consumer itch-scratching shopping binges all but nonexistant. There will be glory for both teamwork and individual contribution, but precious little room for unproductive self-involvement. Despite the dependence on high technology, there will be a new partnership with nature in ark-sized biospheres, a heightened sensitivity to our symbiosis with plant and animal life; a realization that man and living nature thrive together or perish together.

Such prospects appeal to many environment- and ecology-sensitive persons in the Mother Earth movement, types that many of us space advocates customarily dismiss as not worth courting because these crusaders often seem to yearn for throwing out the technology-baby with its bath water. But this is constituency that can enrich us and provide a strength in alliance that we will never realize if we disdainfully g it alone. If we love our cause, we’ll set our egos aside and patiently woo these concerned and energetic individuals. Let’s go together, those of us with the right stuff! The rough edges of this frontier are a rasp for personal and cultural baggage best left behind. -- Peter Kokh 5/88

GLASS GLASS COMPOSITES

By Peter Kokh

Glass-glass-composites, more exactly glass-fiber / glass-matrix / composites, or simply GGC, are a promising new horizon for construction and manufacture. This new bird in the flock of materials available to man is still inside the eggshell but pecking away at it. What we know of GGC's promise we owe to Dr. Brandt Goldsworthy of Goldsworthy Labs in San Francisco, who at the request of Space Studies Institute in Princeton (SSI) made laboratory-sized samples and investigated their properties (his report is available for 3$ from Space Studies Institute, PO Box 82, Princeton NJ 08540). His work gives reason to believe that GGC building materials will be as strong as steel or stronger, and considerably less costly in energy terms to manufacture.

The occasion for this bit of incubation of a theoretical hunch lies in careful analysis by SSI of the possibilities of producing serviceable metal alloys from the common ingredients in lunar soil. While the Moon is rich in iron -- some of it free uncombined fines -- and other important metallic elements such as aluminum, titanium, magnesium, and manganese, these are just starting points; to make alloys with good working properties, other ingredients in lesser amounts must be added. It turns out that our customary and familiar stable of alloys used on Earth often require recipe ingredients that are not easily or economically isolated from the soil. Furthermore, alloy production takes a great deal of energy and therefore represents a technology direction for a very advanced lunar civilization, and not one for an

early base trying to justify its existence with useful exports to LEO or elsewhere. Alloys will come on line someday; it will take young metallurgists without defeatist attitudes ready to scrap Earth-customary alloy formulations and experiment from scratch with available elements until they have a lunar-appropriate repertoire which will serve well. But that is another story. Here we want to explore the tremendous potential of GGCs.

A "Spin-Up" Enterprise Plan

But how can we explore the potential of a laboratory curiosity? We can't. Are we to wait until we get to the Moon and then fiddle around, hoping that we come up with something before the base has its next budget review? You would think so from the present dearth of activity.

Why not haul GGC out of the lab and put it through its paces in the real world? Sure that takes money, but with a little imagination it is easy to see that GGC could become a profitable industry, here and now, on good old Cradle Earth. And if so, our newly acquired expertise and experience will be ready to go whenever the powers that be establish a long-term human foothold on Luna.

What is the realistic market potential that would justify the effort and expense of getting off our bottoms and pre-developing this promising technology now? If we are talking about something only useful for industrial construction material, then the threshold for successful market penetration is high. Our GGC products must come on-line either cheaper than every competing material or have such superior properties as compared to existing alternatives as to force potential customers to take the gamble. But to limit ourselves, especially at the outset, to such a line of products is not only accepting unnecessary barriers to success, it evidences a great lack of imagination.

Does GGC have a potential for consumer products? This is an important question, for with such products cost can be secondary to other considerations such as visual appeal due to inherent special design and style possibilities, etc. The consumer market could be a much easier nut to crack, and once established and experienced there, our infant industry would be better poised for market entry in the indus-trial-commercial world.

Before we speculate further, we must take a look at this intriguing new material and put it through the paces to see what we can and can't do with it. Without that, we are building castles in the sky.

We have a logical plan of attack for these experiments thanks to the analogy of GGC to a long familiar family of materials with which we have abundant experience: fiberglass reinforced plastic resin composites, the stuff of which we make boat hulls, shower stalls, pick-up toppers, whirlpool spas, corrugated porch roofing, and a host of other handy products.

Fiber reinforced plastics or FRPs offer the game GGC entrepreneur a handy agenda for exploring the talents of the new material.

First our enterprising hero will want to see what fiberglass-like fabrication methods GGC is amenable to mimicking. Can (or should) the still hot and workable glass matrix with glass fibers already embedded be draped over a mold to take its form, or be compression molded in a die and press? Can (or should) the glass fiber be set in the mold and then impregnated with the molten glass matrix? (The magic of GGC lies in using two glass formulations: one with a higher melting point from which to make glass fibers, and one with a much lower melting point to serve as the matrix in which the reinforcing fibers are embedded.) Can (or should) the glass fibers be first impregnated with a cold frit of the powdered glass that will form the matrix upon heating in the mold to its fusing point? Once the entrepreneur has learned which fabrication methods work best or can be adapted to the idiosyncrasies of GGC in various test formulations, he is ready for the next round of experimentation.

Fabricating a "piece" of GGC of a certain useful size and shape is only the first victory. We must learn how to machine it: can the material be sawed, drilled, routed, tapped, deburred, etc.? We need to know this before we can design assembly methods. If adhesives are to be used, what works best? Thermal expansion properties of GGC formulation will be important, as well. Once our entrepreneur has done all his hands-on homework, knows what he can do with this new stuff, and has outfitted his starter plant with the appropriate machinery, tooling, and other appropriate equipment, it's time to sit down with his market-knowledgeable partner and decide on product lines.

But let's back up a moment. We said we were going for the consumer market as the ideal place to get our feet wet, and for this market one thing is paramount: visual appeal. So we go back to the lab

and start playing around with our formulations. Glass of course is easily colored. Coloring the matrix glass will not provide us with a distinctive product. But colored glass fibers in a transparent glass matrix suggest tantalizing possibilities. The fibers could lie in random directions, be cross-hatched or woven, swirled, or combed to give an apparent grain. We will want to see which of these suggestions are most practical, which have the most stunning and distinguished consumer eye-appeal, etc., all without compromising the strength of our material. As to the colors: black, green, brown, blue, cranberry, and amber would give us an ample starter palette. But before buying up bin fulls of the needed ingredients we could do some inexpensive footwork, using abundant and inexpensive green and brown bottle glass for our fibers to give us a first feel for likely results of this avenue of product enhancement. Our homework done, we're ready to burst onto the world scene.

Our recycled long-empty plant (the rent is cheap and a lease wasn't necessary) has been humming for a while now. Production hasn't begun because the designers are still working on the molds and dies for the introductory product line. Buyers and outlets are being lined up. At last Lunar Dawn Furniture Company is ready to greet the unsuspecting world. At first we produce only (stunning of course) case goods: coffee and end tables, etageres and book cases and bedroom sets, etc. Then we introduce a line of tubular patio furniture that makes the PVC kind look gauche. Next we branch into an upholstered line with beautiful external frames. Office furniture, striking unbreakable fluted glass lamp shades, stair and balcony railings, and unique entry doors are our next targets. Our prices are somewhat high at first, at least with the initial lines, but we were the rage at the fall furniture show in North Carolina and the spring Home Shows in every town. Lunar Dawn takes it's place beside Early American, Mediterranean, Danish Modern, and Eighteenth Century English.

We introduce less expensive but still appealing lines and franchise our operations, targeting especially the less developed nations that need to curtail their forest-razing and which have an abundance of the raw materials needed for glass making. But we also begin to diversify into the commercial and industrial markets. We've learned to make beams and panels and now offer a whole line of architectural systems for competition with steel and aluminum pole buildings, etc. One of our branches is now marketing GGC conduit and pipe at competitive prices. Another is offering a full range of clear non-laminated safety glass for buildings and vehicles.

Meanwhile, we are not resting on our laurels in the consumer world. Casings for small appliances, cookware, ovenware, and table ware; handles, wash basins, and countertops; boat hulls for boulder-studded white water use; all are now available in GGC. A big hit with the fans is our indestructible flagship in the sports world, our GGC bodied Demo Derby Dragon. The same car has won its first dozen events and looks none the worse for it.

Of course, we've long since abandoned the cumbersome GGC or Glass-Glass-Composite tags. The public got what it needs, a simple one syllable pigeonhole. We're known and recognized everywhere as GLAX, a word suggesting glass with a difference: strength. And visually, the "ss"-replacing-"x" even suggests the dual composition involved. Glax is a generic term like steel or wool and even has its own generic logo, a symbol for public recognition and promotion.

You'll see in the logo symbol an allusion the Moon. For the ulterior motive inspiring the people behind the successful Glax entry into Earth markets was the need to predevelop a technology suited for early lunar bases and settlements. Glax will provide a relatively inexpensive, uncomplicated industry for the settlers both to furnish badly needed exports, and just as important, a whole range of domestic products that will help hold the line on imports. As such, Glax is an essential keystone in the plan to achieve economic viability and autonomy for the projected City.

There is a lot of enthusiasm on Earth now, not just for a lunar scientific outpost à la Antarctica, but for a genuine settlement. This change of attitude did not happen by accident, and the story of Glax on Earth played a major role in this turn of events. Glax, since the first door-opening day of Lunar Dawn Furniture Company, was aggressively marketed as an anticipatory lunar technology. The public began to get the idea that moon dust might be good for something and that the idea of a self-supporting settlement relying largely on its own resources was not a flake notion, but rather something reasonable, even to be expected! Lunar Dawn helped the process along when after moving into its brand new plant in suburban Milwaukee, it built a simulated lunar home next door, soil-sheltered and all, with solar access, periscopic picture windows, ceramic, glass, and metal interior surfaces, and of course furnished with its own Glax furniture lines. The habitat was accessed by "pressurized walkway" from the meeting

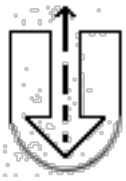
hall-display room-library-computer network room and gift shop built alongside and used free of charge by Milwaukee Lunar Reclamation Society.

How did this all happen? Notice the fine print on Lunar Dawn ads and billboards (also used in connection with other Glax product companies): it reads "An Ulterior Ventures Company". Ulterior Ventures isn't some big conglomerate but a unique venture fund which the National Space Society helped to organize to give entrepreneurs willing to predevelop anticipated lunar technologies for Earth markets, a little help to get started. Successful members of the Ulterior Ventures family pay a royalty which helps build the fund for even more ambitious exploits. In future articles we hope to tell you about other successful -- if not so well known -- members of the Ulterior Ventures family.

Future Fact or Science Fiction?

Fiction? Yes. Unrestrained flight of fancy? No! This is the sort of thing that could happen with space enthusiast encouragement, if we can collectively be persuaded to show the same enthusiasm for direct action as it always has for indirect agitation "to make it happen". Having to start from scratch to build the infrastructure to incubate and support such "ulterior ventures" would mean an unwelcome set-back in time, effort, and personal energies.

The brand new infant industry sketched above does not require expertise in preexisting sophisticated technologies to get started. Almost any of use could get in on the ground floor of such an endeavor in one or more capacities. Any takers? -- Peter Kokh May 1988


Left: a proposed "logo" for any future **Glass-Glass Composites** industry

Right: Logo for the **Ulterior Ventures Fund** suggested in the above article on Glass Glass Composites. The larger downward arrow, for the terrestrial applications that support the research and development, give rise to the upward arrow, putting "on-the-shelf" technologies that will be needed on the lunar and space frontiers. Interest and/or royalties on venture funds will support further ventures.

JEWELRY

Dressing Up in the Settlement with "Made-on-Luna" JEWELRY

By André D. Joseph and Peter Kokh

For some, nothing in life could be more unimportant or irrelevant than jewelry. They would prefer to do without, thank you. For others, it is a matter of putting on the dog, asserting status, class, sophistication -- something more than individuality. Then there are those gypsy souls who only seek cheerful decoration and for whom the true or perceived market value of their baubles is meaningless.

No Gold, Silver, Platinum, or Copper

Using Iron, Aluminum, Magnesium instead

What materials can Lunan artisans use to create ornamental items to wear? The time-honored jewelry-making metals of Earth - gold, silver, platinum, copper - and their alloys will be extremely hard to come by as they would seem to be present on the Moon only in minute, non-concentrated traces.

Magnesium can be worked if it is heated to about 400° F but is dangerously reactive with the oxygen in the air [magnesium is the basis of fireworks.] But Aluminum, that once precious but now mundane and pedestrian commonplace, can be worked cold. So we might assume that some aluminum

alloy would become the metallic medium of choice for the jewelry maker in Luna City. But bear in mind that iron will be the cheapest metal to produce on the Moon and here and there in Earth's past it has been pressed into service of adornment.

Diamonds and Gemstones

Given rediscovered metals to work with, what can be added? It is probable that diamond dust of meteoric origin is a widespread trace. But diamonds of visible size seem unlikely, as they are constituted carbon, with which the Moon is not naturally endowed. Synthetic diamonds and cubic zirconium? In time, perhaps, when there are enough settlers and enough demand. Many other gemstones such as ruby, sapphire, amethyst, agate, onyx, jade etc. might possibly have formed at great heat and pressure deep within the Moon and brought towards the surface, as on Earth, by past episodes of volcanism. The elements for their recipes are certainly present,. But we won't find them on the highly pulverized surface. Just possibly, future Lunan "spelunkers"will find some here and there in the lava tubes we know to be present in the layers of solidified mare lava sheets. If not, synthetic rubies and sapphires can be made from aluminum oxide (corundum.)

Pearls?

At a premium representing the non-native carbon ingredient, pearls could be cultivated in lunar oyster beds. At a similar premium for non-native carbon content would be dried and carved peach pits, a Chinese art form, and small decorative items made from such hard and richly grained orchard woos as apple, pear, and cherry. Indeed, given its character and the pressures for not withdrawn it in quantity from the biosphere cycle, would might be one of the most sought after media for bauble-making on the Moon or in free-space oases.

Ceramics and Glass

By far the cheapest "stone" will be such all-native-content creations such as glazes ceramics, synthetic crystals and clear colored glass. Gems of "paste" are actually a very hard form of glass with a high lead content. Lead will be quite scarce and potash glass might be the next choice. Another route will be vitreous enamel glazes on metal similar to cloisonné but filing carved bas relief bays in the aluminum rather than bays created by superimposing gold wires on a brass base.

As was already mentioned in a previous article "Apparel" [MMM #13] glass bead work and metal chain mail will certainly be viable forms of expression for frontier artisans. Perhaps, too, some ordinary moonrock breccias, when cut and polished will have satisfying appeal.

Play Jewelry

For temporary recyclable "play jewelry," gaily colored papier maché items, maybe glitzed up with seeds and kernels, would be one choice. And a necklace strung with bits of pyrites (FeS, fool's gold) might bring a smile to any Lunan lass.

Concentrating on the practical

Jewelers might concentrate on more practical items such as buttons, belt buckles, hair clips, scarf rings etc. than on purely superfluous items as necklaces, bracelets, rings, broaches, and earrings. Making artfully what must be made anyway is a more honest function, and these sorts of values will be a badge of the frontier. Jewelry of export will serve mostly a souvenir function, until the proficiency of Lunar artisans working in new media comes into its own. MMM 5/88

MMM #20 - November 1988

CERAMIC CITY
By Peter Kokh

There are several building materials options for lunar based industry. Among likely candidates for early demonstration are lunar concrete (one part in 224 [per T.D. Lin] represents the hydrogen content of water and will probably have to be upported at great expense,) lunar glass-glass composites, sin-

tered iron, and cast basalt and ceramics. It is this last ceramic option, about which the greatest amount of disinformation exists, some of it in bad faith, the rest simply inexcusable.

A recent book "Space Resources: Breaking the Bonds of Earth" by John S. and Ruth A. Lewis is a case in point. In it, the prospects for lunar development are dismissed with the flippant "what does one do with [brittle] basalt bricks, is a neat question, one that we have been unable to answer." Unfortunately, this book, and this section in particular, received a critically unquestioning review in a recent issue of **Spacelines**, unintentionally helping to spread the disinformation further.

Enter Nader Khalili, an Iranian with a vision, living in this country, and working around the world. The man is driven by a desire to provide low-, or even no-cost housing for the world's teeming billions. Familiar with Iranian adobe structures, to which there is some resemblance by the far less developed adobe architecture of the American Southwest, he has concentrated on clay and adobe building shapes and styles that lend themselves to being fired and glazed from within to form far stronger, more durable structures than the original unfired ones. His word for this is **Geltaftan** from the Iranian (Persian or Farsi) for "fired structure." His vision then, is a home for everyman, not erected of costly building materials, but fashioned from the native soil of his homesite, in situ [in place, on location.]

Khalili has gone beyond this, however, to experiment with ceramic sidewalks, retaining walls, underground storage tanks, irrigation ditches, etc. all dug/formed on the spot, then fired and glazed. His vision extends to stabilizing eroding cliffs and advancing sand dunes by firing them, to fashioning building slabs and other elements from molten lava fresh from active volcanoes, and to the Moon.

Invited to deliver a paper at the October 1984 symposium Lunar Bases & Space Activities of the 21st Century organized by NASA Johnson and held at the National Academy of Sciences in Washington, DC, his remarks were greeted with enthusiasm by the unsuspecting audience of "experts."

Let us fast forward to, say, 2020 and read the following letter from a pioneer in his eyes.

Dear Mom and Dad,

How goes it down there amongst the green hills of Earth? Things are really picking up for me here up grayside.

Today (it's sunrise here on what we optimistically call the "Garden Coast" of Mare Crisium) I began work for Geltaftan-Luna, the settler-owned construction company that is building Port Tanstaafl. At sunrise the company yards came to life as actual construction work depends on concentrated solar energy. During the preceding fourteen days of darkness, workers put together the forms and molds we will use, sifted lunar soil, overhauled machinery, and did other non energy intensive work in preparation for the nest two weeks of busy city-building now upon us.

At dawn, the great mold-wheels of assorted diameters and depths were filled with the first of their carefully measured portions of sifted lunar soil. (That's my job - a bit humble, but it's a start!) Then the great solar furnaces come to life concentrating the fire of untamed sunshine and directing it through a heliostat onto the soil charge in the bottom of the mold-wheels. As the charge melts (mare soil, being basaltic, has a very low viscosity and flows freely) and the mold-wheel begins to spin, the born-again magma flow easily over the reinforcing fiberglass mattes (made of nearby highland soil with a 360° F higher melting point) and around the carefully designed and precisely placed plugs that will be openings for doorways, indirect skylights (to be fitted with sun-following heliostats) and even for periscopic picture windows. These openings owe an inspirational debt to the wind-catchers built into ancient Iranian adobe buildings.

The mold-wheels are precision shaped to have a parabolic catenary curve and the resulting fiberglass reinforced cast basalt domes will have maximum strength in compression (from the soil overburden in case of habitat decompression) and tension (from excess air pressure within, not quite wholly compensated by the weight of the

soil backfilled above.) The domes have a reinforced inner lip to securely anchor the floors which are fused in place one the domes are erected on their sites.

After the domes and floors have cooled down, the interiors are given a "sodium glaze" closely related to the salt glazing commonly practiced on Earth. The glaze is applied under high heat with first pressurization so that it is really forced into every last pore to make the structure quite airtight. Moldings for hanging pictures or some of those pretty fiberglass tapestries are already built in - you don't dare try to make a nail hole! Some settlers put a sort of lime whitewash over the glaze. Others like the slightly browned (from the sodium) gray tones as they are.

Just as lathe workers learned long ago to produce more than simple turnings, Geltaftan\-Luna has some very sophisticated mold wheels that turn out tunnel and conduit sections, vaults and apses, and other more complex elements of the modular city-structure. We also make elements that are not turned such as paving slabs, water-tight plant bed-bottoms for the farms, shade walls for waste heat radiators etc. And we fuse soil outside all the entrances and airlocks to minimize troublesome soil hitch-hiking a rid inside on wheels and boots. While the swiftly multiplying Geltaftan Coop-eratives on Earth use basically low-tech methods, here on the Moon, it is all appropri-ately high-tech or at least precision work. It has to be so, as our environment is mer-cilessly unforgiving.

The great mold-wheels, are, of course, mobile, advancing with the edge of city construction. But some units are built to move rather quickly, for use out-side the city. Next sunth, I get to go out into the field. We will begin constructing a new terminal complex for the spaceport, some thirty miles away, out farther on the mare. Fusing of the new reinforced landing pads was completed last sunth.

In case you wondered how the domes can fit together to make larger structures and the city as a whole, suffice it to say that they best lend themselves to groupings based on a hexagonal grid or honeycomb.Of course this pattern is broken by streets (pressurized, naturally) and cuniculars (pressurized pedestrian walkways or alleys.) Actually, this method of building has a whole consistent language of expression so to speak, and you'd be amazed that he variety of designs Geltaftan-Luna architects have come up with to make the city anything but predictable and boring! Yes, magmatecture, as we call it, is transforming our little corner of the Moon, all from on-site materials, with the result that the city looks (it is!) home-grown, as if it truly belongs here, al-most as a native life-form.

By the way, I am studying Lunar Architecture [LunArch 101, to be exact, as a part time student at U of L. It is really a fascinating and exciting new field, and I feel my future here is wide open.

My Marimba lessons are going well. Did you know that the ceramic tubes used in the Marimbas are made by Geltaftan employees in their spare time? This kind of ex-perimental art and craft enterprise is encouraged by the management, and they will even get you whatever tools you need.

Well, Mom and Dad, its been nice chatting but I've got to get to work.
I'll write again soon,

Love,

Graham

First Souvenir$

Lessons from Mt. St. Helens

By Peter Kokh

Trash to Treasure - May 18, 1980 started out to be a day of spectacular demonstration that human conquest of nature was but a veneer. That was the day that Mount St. Helens blew its top. In time, however, enterprising Washingtonians put the unwanted inches of white ash that buried much of their state to an amazing variety of uses.

To be sure, much of this ash was merchandised tongue-in-cheek. The same people who once fell in love with cute little "pet rocks" at $5 apiece, were now lining up to buy MSH ash for "pet food" for these critters. The ash found its way into novelty gift soap bars, ash ant farms, candles, terrariums, gag salt, pepper, and ash shaker sets, and bean bag chairs.

Ash-filled souvenirs soon appeared such as paperweights, pens, good luck charms, hour glasses, etc. But what caught my interest immediately was the way in which serious local arts and crafts people quickly found ways to express themselves in this suddenly abundant ash-cheap new material. Potters, glassmakers, sculptors, and painters all began experimenting with the stuff and producing items of exceptional character and beauty.

Lessons for early lunar entrepreneurs

What in the universe, you ask, does this have to do with the Moon? The answer should jump out at you. The previous article, FIRST EXPORT$, highlighted the SSI brainstorming idea that the glass nodules and iron fines in the tailings from the lunar soil run through a pilot liquid oxygen production plant could fetch a high price on Earth if turned into novelty jewelry and coins 'made-on-the-Moon'. The assumption here is that the vast bulk of the ash-like soil could not be turned into comparable profits. Not so!

'Made-on-the-Moon' Fad

I do endorse the glass jewelry and iron coin idea for an icebreaker lunar enterprise since the 'made-on-the-Moon' aura will definitely add extra market value to the extraterrestrial origin of the material itself. BUT the artistic quality of such 'machine-made' trinkets and the number of people who will want to pay the price both work to limit the potential of this gambit.

Lets See What Earthbound Artists & Craftsmen can do with Moon dust & rocks

This “Junior Chamber of Commerce” effort should be immediately followed by a bi-world enterprise in which a group of human artisans commissioned by the venture company fetching the lunar soil, would turn the common 'Moondust' into objects of more genuine beauty, right here an Earth. The price of their works could be kept high by the simple device of using the Moondust as an accent, a garnish, an ingredient adding striking character to objects the bulk of whose materials are Earth-derived, The results would be nonetheless authentic and certified LUNAR SOUVENIRS. To illustrate:

- **Moonscapes** created with lunar soils of various shadings in an earthly glass-glass sandwich (wall-art, jewelry box lids, pendants, votive candle glasses etc.)
- **Fine terrestrial glassware** (bridal registry quality or prestige barware) with etching like patterns made with lunar fines.
- **Decorative mirrors, clock faces**, and other items made similarly.
- **Fine earthly china and pottery** in which Moondust is used as a striking glaze accent. Lamp bases and glass shades, candlestick holders, book ends made similarly.
- As colored glass fiber combined with earth glass matrix in striking and illustrative **glass-glass composite (GLAX*) creations** from paperweights in 1x4x9cm '2001' monolith style to luxury door knobs and pulls, 'Moon-pearl' necklaces and earrings, abacus beads, and prestige desktop name plates.

And this is just a starter. Homework can be done now, both with MSH ash and using some of the lunar simulants available at $1/lb. The possibilities are far more numerous, the attainable quality

higher, and the market far less shallow for items made-from-Moondust-by-an-artist-on-Earth than those made-on-the-Moon-by-machine.

[Special thanks to my sister Mary Wegmann and to Jack Estes both of Peninsula College, Port Angeles, Washington and to Carla Rickerson, head of the Pacific Northwest Collection, University of Washington Libraries, Seattle, for their research assistance and suggestions.] **MMM**

an Early Pioneer Craft Material?

On the Moon, Shorn Hair May be Zealously Saved for Various Uses

By André D. Joseph and Peter Kokh

In the early lunar settlements, many of the arts and crafts materials we take far granted will be scarce, if not altogether unavailable. Ceramics, glass, and sintered iron will be the probable mainstays for the Lunan artisan.

A scarcity of "soft" art & craft stuffs

Byproducts of the colony farms such as wood, pulp suitable for making craft papers, natural resins, etc. are not the easy answer. All such items contain about 50% exotic elements - lunar sources of the hydrogen and carbon components of organic matter may have to be supplemented with imports at great expense (the major savings in on-Luna agriculture will come from using lunar oxygen for the other 50%). There will be considerable economic incentive to recycle all agricultural 'waste'.

Some such products, however, might well do temporary duty as craft materials for children, for example corn cobs and sheaths, as such 'works of art' are seldom long treasured and could be eventually recycled. But permanent withdrawal of such expensive organic matter from the biomass cycle will perhaps be all but taboo and governed by strict regulation.

Recycling in lunar and space settlements must be very thorough to be effective. The penalty for not pursuing this religiously would be a much lower standard of living for the settlers. A greater portion of the income earned from the settlement's exports would then have to used to replace squandered volatiles, instead of for badly needed items to make life a little less harsh, or for imported volatiles intended for biosphere growth.

Making an exception for hair

A point of diminishing returns will be reached, however, and it would serve no purpose to carry recycling efforts to suffocating extremes. We would like to make the CASE FOR AN EXEMPTION at the outset. Let us decide beforehand, that any settler has the right to keep, without penalty, his or her own shorn hair 'for the purpose of self-adornment.'

Hair in the History of Arts & Crafts

Hair? Yes, the history of folk arts & crafts shows that shorn hair can be used in many ways that will make the edges of frontier life just a little bit less rough. To be sure, hair is not a widely used material in today's sophisticated craft scene! But this is not the only art and craft area in which early Lunans would do well to research the folk ways of times gone by.

Our first suggestion is quite obvious. Young girls could let their hair grow quite long. Their locks, when finally cut, could be made into falls, braids, and wigs that they could later don for dress-up occasions as blossoming teens or as mature women. (Young boys could do the same, if distinctively masculine styles of managing their long hair were used: turbans, anyone?) Even settler recruits might adopt as an honored custom the practice of letting their hair grow out, to be shorn later upon arrival in the settlement.

Hair as a macramé stuff?

Such shorn hair could also be done in macramé style with made-on-Luna beads and rings, and first worn in sort of a 'coming of age' event. This would all be but one small item in an increasingly distinctive Lunan culture. Hair based macramé could be used as well to fashion tasseled head bands and belts and interesting shoulderettes or shawls.

NSS Chapters Administrator Aleta Jackson ['89] points out that the Romans wove long maiden hair into luxurious ropes. These could be used for waist sash cords, purse handles, sandal uppers, etc.

Artistic use of short clippings!

We take for granted that in early adulthood and for most of one's life, frequent haircuts will probably be the rule. SAVE THOSE CLIPPINGS! They can be caught as they drop and carefully sorted by color.

In the past, such clippings have been successfully ground up and used for craft pigments and stains (the characteristic palette of available colors will be small). 'Hair painted' home-fashioned shirts and blouses, ties, skirts, and hankies etc., could become a distinctive settlement craft much sought after by tourists from Earth.

In the past medium length clippings have been painstakingly arranged in inlay and mosaic 'landscapes' and 'paintings.' Usually, the motivation behind such time-consuming work was to provide a treasured memento of a beloved departed one. But no matter; the point is that it can be done!

Hair as a composite stuff

Hair waste has also been combined with a resin to make rich looking beads and buttons. Even those combs which are worn by women to keep their hair in place could be made of their own shorn hair!

Recycling as the last resort

What about shorn hair unsuitable for any of the above self-adornment uses? This can either be placed in the appropriate compost bins or used as doll hair or stuffing, again to be ultimately recycled (unless of museum-bound quality!).

REFERENCES:

The Milwaukee Central Library's Art and craft reference collections contain only a few entries on the use of human hair but these seemed promising enough to warrant this article. We are sure that a more thorough search of folk customs worldwide would bring to light additional interesting possibilities.

NOTE: Frontier Hair Cosmetics

While on this topic, we must keep in mind that the preparations available (and allowable!) to Lunans for hair care will be almost certainly limited to natural, minimally processed ones. However, this is all the people of earlier times had to serve their needs. **MMM**

MMM #26 - June 1989

TOY CHEST

By Peter Kokh

On the Moon or in a Space Colony, will children's toys be imported? Most likely there will be severe restrictions - a matter of priorities - on which kinds of items such settlements can upport from Earth. During the early decades of scarce volatiles, the only luxury items that may be permitted in this up-the-well traffic are likely to be those made largely of strategic metals (copper, platinum, gold, silver) hard to extract economically on the Moon; of easily reduced simple plastics like polypropylene; and finally of biodegradable matter low in-oxygen (e.g. beeswax can be melted down at 145°F to be recast in new shapes).

The noble metals are very unlikely to make the journey as toys, even temporarily, since their urgent need is in indus-trial applications. Plastics are the subject of the following article. Beeswax and

other waxes are more likely to come as packing material rather than pre-molded miniature animals, astronauts, or phaser guns. It is quite clear there will be no TOYS-R-US in either a Luna City or some New Tucson colony at L5.

Rather the settlers will have available to than a limited inventory of toy stuffs and will learn to do quite well within such limits, as have all peoples before the current consumer paradise. Considering that toys in general are rupture-active with a half-life of about a week after purchase, there might be some relaxation on using soft wood from trees grown in the frontier community, provided it is not fouled with treatments of any sort (e.g. stain, paint, varnish) that would prevent its being eventually biodegraded. A good use of wood would be for modular toy construction kits: Lincoln Logs and Tinkertoys etc. (curious wonders of long ago). If silicon-saturated rubbers can be formulated, toys as well as tires will employ them.

Other biodegradables that can do 'detour duty' as temporary toys, in addition to the moldable and carv-able beeswax already mentioned, are corncobs and husks - used by many cultures, seeds, kernels, and nuts for toy jewelry, beadwork, and mosaics; egg shells for decoration; and for modeling, organic play-doughs made from flour, water, salt, and sometimes baking soda. Helping the cook prepare such fancy but transitory table fare as decorated cakes and gingerbreads can serve a creative play function; and so can simply arranging given colored items about the home in pleasing still-life creations.

The cuddliest stuffed animal is a living non-stuffed one [see "Animal Life" in MMM # 8 p.6]; and in a world ungraced by outdoor wildlife, pets will be especially important. But for artificial substitutes, space frontier folk should be no more hindered by the unavailability of soft foam, pliable synthetics, and other modern toy stuffs, than were the hardy pioneers inhabiting Earth in more rugged times. Old clothing (to be reborn as rag dolls and rag animals) and such items as raw cotton, seeds, corn silk, feathers, even shorn human hair can do toy duty.

Yarn seconds and looms should be available. Wood, wax, soap, even potatoes are used for temporary carvings. Recyclable home craft papers for wax crayons with unprocessed vegetable dyes or for water paints of the same simple composition present no problem. A library of books on old folk arts and crafts, toys, dolls, and games, should be of more than historical interest and inspiration to pioneers of this new frontier.

Toy vehicles (hopefully soil-moving equipment, prospector 'jeeps', over the road rigs, and sundry spacecraft rather than battle robo-tanks) can be made of cheap sintered or die-cast metals as they were prior to mid-20th-century before plastics became king. But all toys should be modular in construction, with parts that snap together in a variety of ways to develop the child's imagination, rather than specific fixed adult-designed offerings that disable the imagination. Board games will see cardboard and plastic replaced with glass, glass composites (GLAX*), ceramics, and sintered iron, enticing the craftsman to produce them with heirloom quality.

In general, however, given the small population and market, the selection of finished, ready-to-play-with toys avail-able to the pioneer shopper will be small. Kits out of which a variety of such toys can be created in the exercise of one's imagination will be the rule. This will certainly be one of the healthier facets of the micro-market economies of the space frontier. But as the number of mutually trading frontier settlements grows, this wistfully idyllic situation could change.

Recycling will be 'the fourth R', a necessary ritual for the settlers, quintessential to their survival and prosperity. In large measure, the collection and primary sorting of recyclables will be the duty/chore of older children. It would be natural to scavenge such binnage for items with toystuff potential. And so when it comes to making finished toys, this enterprise may be left to the more artistic and craft-handy among these older youths with the younger children as the beneficiaries. This would help keep most adults free for the more pressing productive needs of the community.

MMM

THERMOPLASTICS

A Subsidizable Import for Many Uses

By Peter Kokh

Although it is rich in oxygen locked in its soil and rocks, the Moon is volatile poor, very poorly endowed with the other life-supporting elements: Hydrogen, Carbon, and Nitrogen. There is indeed a reservoir of these gasses adsorbed to the fine particles of the lunar soil through eons of incessant bombardment by the solar wind [see "Gas Scavenger" in MMM #23]. While we will certainly 'mine' such reserves to the extent that the methods for doing so are cheaper than wholesale upport from Earth, we will probably need more of these elements necessary for water and biomass than we can extract from routine soil-moving construction projects or as a byproduct of mining operations.

[The high cost of such vital elements will provide a strong motivation to develop the small Martian moons, Phobos & Deimos, thought to be rich sources of hydrocarbons. Despite their distance, the fuel needed to fetch volatiles from these two low-gravity worldlets is but a third that necessary for upport from nearby Earth.] These same elements are basic to most plastics (nitrogen is used mainly for nylons; same plastics involve chlorine and fluorine). Until hydrogen and carbon become dirt-cheap on the Moon and Moon-supplied space colonies, it will be rather uneconomical to make anything of plastics that can either be made of something else, or simply done without. This will be the case for the early years on the space frontier.

In general, plastics fall into two broad categories. Thermosetting plastics, commonly based an urea resins, set when heated and cannot be remolded. The only way to recycle items made of thermosetting resins is to incinerate them. Incineration, in small totally closed environments such as a space colony or lunar settlement, could only be permitted if it was so thorough as to emit nothing except water, carbon dioxide, and benign recoverable ash. The standard of absolute purity required, would be difficult to realize in any economical way - though Earth's own need will drive experimenters to work towards this elusive goal. An expensive compromise would be to incinerate such items in a facility isolated from the rest of the settlement biosphere, recover scrubbed steam and carbon dioxide, and exhaust noxious emissions to the outside vacuum to be carried away harmlessly by the solar wind, but forever lost to reuse.

The only alternative to incineration is simply to discard items made of such materials, thus permanent banking - and wasting - their precious exotic (exo-lunar) content. This very high volatile replacement cost for thermosetting plastics will demand that they be absolutely reserved for those very few items that can in no way be made of any other material. Esthetics, ease of manufacture, through-color, light weight, easy-care and other luxury considerations will be no match far the harsh reality of lunar biosphere economics.

Ninety percent of everyday plastics, however, belong to the second category: THERMOPLASTICS. These materials set through cooling, and can be either reheated and remolded, or shredded and refused. That is, thermoplastics are recyclable if need be, and the need will be on the early frontier.

Nonetheless, four observations are in order.

First, even if recycled, thermoplastics tie up elements that could be used to increase the size of the biosphere to make it healthier, more self-maintaining -- the priority. Despite their ability to be recycled, thermoplastics should only be used on the frontier when wares of non-exotic composition (metal alloy, glass, glass composite, ceramic, etc.) would make totally unsatisfactory substitutes.

Second, to have efficient recycling, it is indispensable to have error-free easy sorting of materials of different formulations. The surest way to do this would be color-doping according to a set assignment-protocol. This would mean forgoing all the neat tricks manufacturers use on Earth to disguise the character of materials and thus defeat recycling in advance. This stricture will be accepted, once the benefits of materials-honesty are seen. While in general, each kosher plastic with a mainly functional use would be available in only one hue, a formulation chosen for children's toys could be made in a full spectrum of colors IF it was further distinguishable, for example, by brightness, translucency, or iridescence. A color protocol can be applied with same versatility.

This and similar protocols of materials and surface treatment honesty designed to insure idiot-proof recycling ease, while designed to make lunar type civilization workable, will offer invaluable appropriate-technology spinoffs to Earth's throw-away society. Remember this when next you hear some dolt whine about space nuts wanting to pollute the universe.

Third, having to give up a plethora of plastics and other synthetics has a strong positive fringe benefit: substitutes made of the inorganic materials on hand will not burn. Fire cannot be allowed in the closed environments of a space colony or a lunar settlement. There are no cubic miles of fresh air overhead for flushing out the smoke. Even the smallest fire must be avoided like the plague. When cheap sources of volatiles and efficient transportation finally make plastics and synthetics an economical choice, space pioneers will be wise to continue to do without them rather than play Russian Roulette with their safety. [Mars, blessed with the elements the Moon lacks, will be the tempting exception, and it may take a catastrophic but hopefully small fire to drive the point home.] By the same token, those thermoplastics which are allowed when substitution is impractical, must be formulated to be incombustible and/or to have NO toxic combustion byproducts. A low outgassing rate is also important.

Fourth, the production of plastics commonly involves byproducts (often toxic) for which no use is readily found. Thus it will be far cheaper, considering transportation costs alone, to have admissible plastics produced where the raw materials are (Earth, Phobos etc.) than to import raw feedstocks only a portion of which will end up in the ultimate product. Basing a synthetics industry on feedstocks of plant resins, waxes, and oils homegrown on the Moon saves nothing if the hydrogen and carbon involved has to be brought in from elsewhere in the first place. Only those lunar agricultural products which incorporate lunar-sourced oxygen and/or silicon provide savings over imports.

The Cheapest Method of Entry by far for protocol-meeting protean thermoplastics will be not as ready-to-use-items but either as packing and packaging materials, or as replaceable items needed aboard the cargo vessel for the trip to the Moon but not for the return to Earth etc.

If the noncombustible standard can be met, polyester and polypropylene may see the widest variety of uses, especially for nondurable uses for which inorganic materials are less suited. Future Articles will look at specific areas in which such plastics may be part of the solution along with ingenious use of inorganic materials.

Biodegradable Plastics to the Rescue?

A recent article in **Science News** [May 6, '89; Vol. 135 pp 282-3] reports on recent attempts to marry starches to polyesters and polystyrenes to provide serviceable plastics that can in effect be anaerobically composted. The starch con-tent, varying upwards from 6-40% (the goal of the experimenters being 60%), gives an avenue of attack for microorganisms. In the process, up to 15 percent of the 1200-carbon-long polyester molecules slowly decay into non-toxic 25-carbon waxes similar to those forming naturally on apples. Garbage bags made of the new material should be on the market within a year.

Terrestrial Spin-up Opportunities

Incentives to solve the “plastics problem” are strong. Plastics currently account for 7.2% of solid waste by weight and 32% by volume with only 0.5% being recycled. But the admitted driver for these experimenters is to find new markets for corn byproducts, i.e. starch. That's fine. It's how the system should work.

But a strong caveat is in order. This so-called 'decomposition' may break down films and other plastic items, but until hybrid plastics are made for which the decomposition is thorough, and until byproducts are produced that are actually taken back up into the biosphere cycle, available for food production etc., such processes which promise a bit of relief for some Earth-bound waste disposal headaches, will not necessarily make these new hybrid plastics good lunar citizens. On the Moon or space colony where hydrocarbons will likely be expensively acquired, they must be recycled full-cycle. So far, the progress achieved in producing "decomposable" plastics has only resulted in a more subtle form of out-of-sight-out-of-mind disposal method that involves indefinite 'banking' of much of the hydrocarbon content. But it's a start in the right direction! **MMM**

FOOTWEAR

FOOTWEAR - By André D. Joseph and Peter Kokh

How settlers might provide for their footwear needs without surrendering helplessly to the expensive upporting of catalog-ordered shoes from Earth, may not seem the most pressing problem facing them. But tipping the balance of the import/export ratio in their favor will depend significantly on attention to a whole host of details. Footwear is such a detail.

Leather is protein and contains carbon, hydrogen and nitrogen. It also contains oxygen which can be sourced locally. Thus leather produced on Luna, all else being equal, will be proportionately less expensive than upported leather. But leather is normally produced by chemical tanning which will be unwelcome in small closed biospheres of the space frontier. Instead, depiling should be mechanical, rather than chemical. The possibility of using readily available untempered solar ultraviolet rays for curing is an option worth investigating. This could be done in a near-surface pressurized facility with an unshielded ceiling of quartz panes. Unlike glass, quartz does not block UV.

Investigators should bear in mind that hides from rabbits, cavies (guinea pigs), and goats will likely be more readily available than cowhide. Genetic engineering may someday allow cultured cure-friendly hide to be grown in vats, without the animal. Above all, the end product must be something that can be biodegraded at the end of its service life.

Synthetics, especially those containing little or no oxygen, are better produced on Earth, especially considering the waste products of their manufacture. Those synthetics which are thermoplastic, i.e. which can be remolded or shredded and refused, might be an acceptable way to provide the desired flexibility and resiliency. Polypropylene comes to mind.

Settlement production of synthetics that are rich in native silicon, all else being equal (recyclable, non-flammable , without toxic byproducts of manufacture) promise to be an attractive alternative, for both soles and heels. **Silicone** chemistry is one of those fields in dire need of further development by chemists who want to speed the day of lunar self-sufficiency.

On the one hand, the need for resilient soles will be less, given the one-sixth gravity. On the other hand, as it will be enormously more efficient to provide resiliency in shoe soles than in volatile-voracious carpeting and carpet pads, the role of shoe soles will be very important. Much greater attention will have to be paid to tread as well, since in sixthweight, traction (starting, stopping, turning) will be proportionately reduced.

Economics -- the high price tag on the upported nonnative (exotic) content of shoe-stuffs -- will affect shoe design greatly, by confining materials chosen for resilience and flexibility to those shoe parts where these assets are most needed. Tall boots seem to be the universal choice of science fiction film producers. But in reality, their use will most certainly be confined to the heavy-duty work situations where generous helpings of such materials are justified and for which there may be no easy alternative to the upport of suitable specialty foot gear from Earth.

Sandals -- (with or without cotton socks) seem a quantum leap more sensible for most other use, In this scenario, sandal uppers would be the principal medium of style, fashion, and variety, Cheap cotton laces, thongs of unprocessed gut, chain and chain mail, glass bead decorated bands, macrame fantasies and woven fiberglass straps, are among the many possibilities, giving ample room for creative cottage industries.

One-piece uppers could be made in canvas, denim, flannel, muslin, velveteen, terry, felt, and other all-cotton fabrics, to be purchaser-decorated. There'll likely be a design requirement that uppers be readily detached from bottoms for ease of recycling the materials involved: kosher assembly, if you will. Interchangeable uppers would allow expensive sole and heel materials to stretch much further.

The authors are open to other suggestions, but remember that only fairy tale princesses can wear glass slippers. **MMM**

COLOR, WITHOUT DYES

NATURALLY COLORED LUNAR COTTON

[Based on an article from Organic Gardening sent to MMM by Andy Reynolds, Rochelle, IL – much thanks!]

If cotton breeding work now well underway in the Southwest continues to yield results, future lunar farms need not set aside premium growing space for dyestuff plants. Sally Fox, a California cotton breeder, is developing a suite of cotton plant strains that produce 'naturally colored' fibers. [Ed. Egyptian cotton has a natural tan khaki color. But the article mentions she started her project after noticing the "beautiful, naturally brown fibers of insect-resistant cotton".] So far she has produced a green variety in addition to a wide range of rich brown to yellow-tan hues. She is now working on a blue, a yellow, and a lavender.

Client organic farmers in Arizona and Texas are boosting production in addition to Fox's own 30 acre California plot. Some clothing manufacturers are exited about the idea of eliminating bleaches and dyes. Clothes, sheets, and knits bearing Fox's Foxfiber and Colorganic trademarks should start appearing his fall.

A Catalog of naturally colored cotton yarn is available now for $3 to **Natural Cotton Colours Inc**., P.O. Box 791, Wasco, CA 93280. Sorry, but the work is proprietary and seeds cannot be supplied to amateur cotton farmers.

This is exiting news for future lunar pioneers. Saving acreage is the least of it. For the use of even organically grown natural dyestuffs would require a definite water set-aside in a closed-loop setup if yarn, thread, and bolt dying is not to burden the relatively small and fragile settlement biosphere.

In "Apparel: Everyday and Occasional [Made on Luna] Clothing for the Early Settlement" MMM #13 MAR '88 [MMM Classics #2] we forecast just such a possibility. We went beyond the scope of Fox's work, however, to suggest genetic surgery to splice in the genes for indigo (organic blue jeans!), henna, carotene, chlorophyll, etc. It should be very gratifying to anyone aware of the enormous challenges implicit in the idea of a viable lunar biosphere to see such work actually underway and bearing results.
<<< **MMM** >>>

NIVICULTURE

Making "economic hay" with SNOW:
A Model for the 'Pioneer Mentality' from Hokaido (Japan's north island)

NIVICULTURE By Peter Kokh

For sunbelters, snow is a curiosity, something that usually happens in the mountains and is good for skiing. Even for those of us in the northlands, snow, while a fact of life year in and year out, arrives in whimsical and unpredictable amounts. But in some snowbelt areas, large winter snowfalls are guaranteed, something people can count on. Hokaido is one of those places. And some people there have begun looking on the yearly endowment as a vast potential resource worth exploiting for more than the Winter Olympics.

Snow is two things: A reservoir of water, and a reservoir of cold.

Most people wouldn't look to snow as a practical source of either, because they have other easier, more convenient options. It takes a mind set change, but entrepreneurs in Hokaido are now making tidy profits

√ using ice for packing vegetables,

√ clean snowmelt water for mushroom growing and irrigation etc.,

√ underground storage of ice for thermal control and energy production. In other words, they are employing a reservoir/dam analog to put snow to better use than uncontrolled runoff, "harnessing" the snowfall-melt-runoff cycle

[In many parts of the world with frigid winters, ice sculpture festivals are an annual popular event: If you are unfamiliar with these, do a Google Images Search for "Ice Sculptures." There is nothing more appealing to an artist or sculptor than "free material." And on the Moon, nothing is more free than moondust (regolith)]

Someday, some of their technologies may find applications on the Mars frontier, both at the edge of the polar caps and with respect to permafrost use.

But the real lesson here is one of attitude - the uncommon ability to look for economic potential in the apparently worthless and unwelcome stuff taken for granted by everyone else precisely because it is commonplace.

Mountain folk treat rocks so, desert folk the sands. It might be expected that lunar settlers will look on the all-covering blanket of loose regolith with a similar contemptuous familiarity. We tend without examination to equate value with scarcity. It isn't necessarily so!

In MMM #22 p4 "**!st Souvenirs"** [MMM Classics #3], we reported on a similar pioneer mind set among the entrepreneurs and artists of Washington State who were quick to explore the economic and artistic potential of the suddenly abundant Mt. St. Helen's ash - accepted as a useless curse by almost everyone else. The pioneer mentality includes the habit of always taking a second look at apparent given disadvantages and handicaps, and a third and fourth look - whatever it takes - until such dubious blessings transform in our perception to reveal hidden opportunities and assets worth exploiting.

The Moon is a world not blessed with rich veins of iron, copper, gold or other ores, offering instead only quasi-homogeneous low grade ores. It is a world with no great reservoirs of water, carbon, or nitrogen. Such resources we require in vast amounts, not just because our life cycle depends upon them but also because we've never had to learn to use them efficiently and savingly. Thus to most, equipped as they are with both the wrong tools and the wrong attitudes, the Moon is a worthless and barren rock. Such people can be dismissed, simply because the real pioneering settlers will "self-select" themselves by their ability to take a second look and see promise and potential where others see only bleak desolation.

To most people, equipped with both the wrong tools and the wrong attitudes, the Moon and Mars are worthless and barren rock piles

Extracting valuable ingredients

There are, of course, several schemes to extract useful metals from the lunar regolith soils and schemes to process usable building materials from them: glass and glass composites [Glax™], ceramics, and cement, etc. Here we'd like to look at ideas for using minimally processed regolith in an appropriate technology Moon-style, if you will.

The most obvious use: shielding against radiation and temperature extremes

The idea of using regolith for shielding mass is a commonplace. Some investigators take this a bit further and for convenience of handling (and rehandling during expansion and remodeling) packing the regolith in sacks presumably brought from Earth, or compacting the soil and then sintering it in brick molds. While this introduces versatile options into the shielding question, it is patently absurd to point to this as a resourceful "use of indigenous materials" - as if importing shielding mass in any form were ever seriously considered. [Tsk, tsk JSC! Perhaps their recent booklet "Using Space Resources" is aimed at mindless politicos or reporters?]

Simple Building Materials and Products

The pioneer mentality will grade, compact and sinter regolith for light-load paving uses (pathways and porches rather than roads), retaining and shade-making walls, and other uses. Work is already begun to look into the feasibility of simply melting the loose soil either with microwaves or solar concentrators and casting it into useful forms and shapes where strength and performance are not critical requirements.

Letting Artists and Craftsmen loose to experiment

Lunar artisans, in addition to using craft materials (glass, ceramics, alloys) processed from the regolith will experiment with raw regolith itself from sundry locations for inexpensive glaze, pigment,

and other garnish. [See the article alluded to above.] Artisans will find ways to work creatively as well with the unprocessed raw glass microspherules that comprise 10 to 30% of regolith soils.

Architects love to express themselves with "native materials"

Lunar architects will make use of commonplace selenological features like craters, rilles, and lavatubes as starting point excavations for building whole settlements, working with the grain of the Moon, so to speak. Areas most might look on as impassible mazes of criss-crossing rilles (e.g. the crater Humboldt) might present themselves instead as prime metropolis-building real estate.

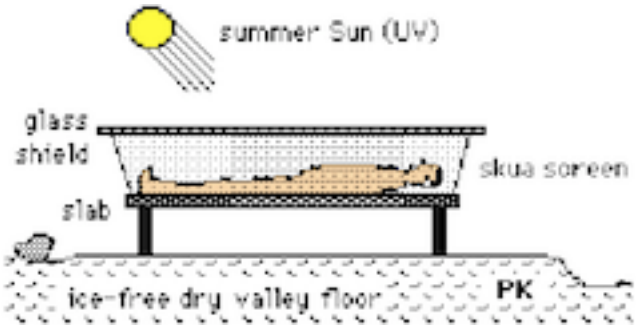
Making Assets out of Obstacles

Someday, enterprising Lunans will find a way not only to mine Solar Wind "leavings" but to put the occasional intense solar flare radiation to work in various industrial processes. Lunan manufacturers out to get a jump on the less imaginative competition, will find a way to use the Moon's apparent overabundance of magnesium and calcium, as well as the unwanted tailings from various processing industries.

Lunan chemists and industrial engineers will pioneer a whole repertory of ways to use NaK (pronounced knack, a "eutectic" alloy of sodium and potassium, i.e. the alloy formula with the lowest melting point). For NaK is the one most abundant regolith-extractable chemical that remains liquid at room temperature and pressures. Similarly, given the scarcity of carbon and hence the expected preciousness of carbon-rich synthetics, new uses will be found for native silicone-based and sulfur-based compounds.

Fast Forward to Mars

On Mars, those with the right mentality will have an edge in finding resources where others see only naked unreclaimable scenery. Such go-getters will find numerous ways to use the Martian atmosphere (97% CO2, 3% N2) as a chemical feedstock for making fuels, plastics, even shielding mass. Others will brainstorm ways to put to use volatile industrial by-products (what we would call pollutants) in the service of slowly transforming Mars' atmosphere and climate into something noticeably more benign and comfortable. The great shield volcanoes of the Tharsis Uplift will be put to use: the warrens of lavatubes running through their bulk as residential, commercial, industrial, and warehouse space; their west slopes used as launch track ramps; their crater rims as observatory sites, even as "desicatoriums" where the departed can lie in rest forever beneath the stars under UV opaque glass canopies , naturally embalmed in the dry thin cold.



A Dessicatorium designed for Antarctic conditions where protection from scavenging Skua birds is an issue

Elsewhere in the Solar System

Everywhere throughout the solar system, pioneers - at least those who will survive and persist and go on to thrive - will do so because they have the right mental stuff - the ability to take a second look at the "obviously worthless." For it is only by finding such latent purchase points that they will be able to carve a place for themselves outside Cradle Earth.

The willingness to experiment with anything free and abundant

For it isn't all going to be adventure and exploration. Success will come from trying and trying again, when most would give up after simply looking at the challenge. Ask yourself if you have that kind of pioneer mentality! If so, as Hokaidan snow harvesting enterprise shows, it is a mental tool you can exercise and sharpen right here on Earth, and make money doing so. You can have all the fun of being a solar pioneer right now! As such, even if you do not personally make it into space, you can be a spiritual ancestor of those who do go and make it. How? MMM will continue to point out the opportunities. << MMM >>>

MMM #49 - October 1990

TRAMPOLINES

Exercise on the Space Frontier

By Michael Thomas, Seattle L5 Society

As we all are aware, one of the major challenges of long term space habitation is maintaining physical fitness. Muscles atrophy, blood counts drop, and bone mass begins to dissolve away in the absence of Earth normal gravity. Of course, there are treadmills, exercycles, elastic penguin suits and other devices to maintain fitness: but who wants to run on a treadmill for 2-4 hours a day like a caged hamster? Such a draconian schedule only contributes to the already significant psychological problems of long term space habitation.

The padded "jogging track" on Skylab was somewhat an improvement over treadmills, but in the absence of artificial gravity via rotation, it's usefulness as a fitness aide was quite limited. What we need is to create a little excitement: something people will enjoy doing. My suggestion is to provide repeated bursts of acceleration, in a most novel form: trampolines.

Since acceleration, when constant, and gravity are indistinguishable, anything that provides acceleration serves for the duration as a source of artificial gravity. Impact with a trampoline results in rapid deceleration and then rapid acceleration in the rebound. While your body presses against the trampoline, you feel a pressure akin to gravity - for the moment. This puts stress, although inconstant, on your bones and muscles as though you were in a higher gravity environment. And while these periods of gravity stressing are brief, they are also numerous. An hour of play could be the equivalent of a few minutes in a more gravid environment depending upon how hard and frequently one impacts the trampoline.

On Earth, one jumps up from a trampoline, then falls back down to it to rebound again. But in a micro-gravity environment, this would not be practical. One would jump so high that it could be minutes or more before one fell back down. Even on the Moon, a single jump would take one many meters high, and it would be stretched moments before hitting the trampoline again.

The solution to this temporal exaggeration is simple. Have a trampoline floor and a trampoline ceiling! This way one is jumping from trampoline, to trampoline, to trampoline,etc. With double trampolines, the force of the impacts would not be determined by the gravitational environment, but by the mechanics of interrupted momentum.

Two factors would come into play: the stiffness of the trampoline and the strength of the jumper, or how hard the jumper pushes against the trampoline while in contact. Accelerations of two or three Earth gravities might be readily achievable by fit persons, even in microgravity. And research into the medical condition osteoporosis (bone demineralization) indicates that such brief accelerations would likely be effective in maintaining bone mass if practiced daily.

There are many possible variations on this "space trampoline" idea. Imagine if Skylab instead of just having a padded track around its circumference, had a cylindrical trampoline so that it's inhabitants could have leapt across its width. They could have maintained a higher level of fitness and had fun doing it. Now imagine that the trampoline were rotating: that it were a centrifuge-trampoline. That would be more of a challenge (and more fun perhaps) to master.

[Editor: If a pair of trampolines were rotating about a common point, the action could be quite complicated, dizzying, and subject to corriolis forces. A lot of experimentation would be needed, in space itself, to come up with a combination that worked.]

Another possibility is a spherical trampoline, held rigid by air pressure, or by [ties to] a[n exterior, larger] geodesic frame. This might be located at the hub of a rotating structure. Or a trampoline court or gymnasium, in which not only the floor and ceiling are trampolines, but the four walls as well. Such a court could be as small as a few meters on a side, or enormous where space and resources permit.

While very stiff trampolines providing high accelerations should be appropriate for very fit persons, less well conditioned individuals could avail themselves of softer, more elastic trampolines that provide lower accelerations for longer periods of time. Trampolines might even be designed for ad-

justability of their stiffness to suit various individual's needs. Many sports might be played on trampoline courts, but I suspect many people would enjoy the thrill of just leaping. <**MT**>

MMM #50 - November 1991

On the Space Frontier [Think Bonsai]

By Peter Kokh

Recently, a student working on the NASA grant Genesis CAD [computer assisted drafting] Project for Lunar Base & Habitat Design at the University of Wisconsin-Milwaukee's Department. of Urban Planning and Architecture, produced an interesting plan in which his base offering was caped by a dome "to give place for trees". A NASA auditor excitedly protested that there was no way we could afford to waste space in such fashion. The student, unabashed, replied that if there were no trees, it would not be a human place, a place fit for human habitation; he stuck with his design.

This little anecdote illustrates a real dilemma. If we can afford to set up a lunar base at all at today's pre-SSTO [single stage to orbit] prices per pound to orbit etc., it may have to consist of sardine cans with perhaps an inflatable annex or two in concession to the need for elbow room. Even if the costs of space transportation fall, spaciousness will still be at a premium until we begin to build added expansion shelter from building materials processed on site (in situ) from lunar resources. This will require getting such technology out of the current laboratory curiosity stage, hopefully before we return to the Moon and start scratching our heads (is anyone listening out there?). The practicality of in situ architecture would be greatly enhanced if we could locally produce low-C [carbon] sealants, to keep import costs down.

But even with new on-line Lunar architecture, pressurized areas will tend to be close-ceilinged, without tree-scale headroom, or more; for the Nitrogen needed as a buffer gas to pressurize extra volume will be a costly import, that is, prior to large scale Helium-3 mining which will yield,.hydrogen, carbon, nitrogen, and other precious gasses as by-products. Of all the "lunar-deficient elements", or LDEs, nitrogen is in shortest supply in comparison to need, the choke-point for lunar operations - not hydrogen as is commonly believed. (Hydrogen, from Earth or Phobos/ Deimos, is best shipped as Methane CH_4, or Ammonia NH_3.)

The student's observation, however, is quite on target. Without trees, we'll have only a caricature of human place, despite the fact that in some desert and plains areas, people do now live without them. Trees have played a critical role in the very appearance of mankind. Arms first became differentiated from legs, to the point that bipedalism was the next step, through brachiation, their evolution to fit the needs of simian predecessors swinging through the rain forest.

Much later, trees supplied poles for making shelters, and first allowed us to master rivers and coastal waters. We felled trunks over narrow streams and eventually milled them into bridges. We "dug-out" trunks for our first boats, accelerating not only fishing and trade, but giving birth to fishing villages along ancient now-drowned coastlines (end of ice age rise in sea levels). Such villages likely well-predate the better known agriculturally-centered villages of the bronze age. Trees have been a far more shaping element in our remote past than ever was the cave. In short, if we ever do come up with an "all-human coat of arms", the tree deserves a place of honor in that design.

All this is over and above the function of the tree in Biosphere I. Second to oceanic algae and phytoplankton, Earth's forests make the greatest contribution to the sweet oxygen necessary to all higher life forms, single cell on up. Forests, even smaller groves of trees, help moderate temperatures, making many areas on Earth more livable. Finally, even lone trees produce shade and serve as place markers.

What place will trees have in baby biospheres? Their dedicated use for ornamental or landscaping needs would be an exorbitant luxury in off-planet towns until the constraints mentioned above are removed. The fragrance of blossoms and the reassurance of luxuriant greenery will instead be provided by smaller plants earning their place through food, fiber or pharmaceutical byproducts, all while naturally recycling exhaled carbon-dioxide into fresh oxygen, and filtering out airborne pollutants that can't be avoided.

Yet, for settlement agriculture, trees remain a highly desirable asset: they'd add greatly to the variety of fruit, syrups, pulp, fiber, and artstuffs etc. - purposes that are less easily satisfied by smaller plants or bushes. Happily, tree "dwarfing" by nursery breeders serving home gardeners has made much progress. Prospects for settlement farms to feature short but fruit-laden apple, orange, pear, peach, and cherry trees (to name a few) are really quite good.

Beyond that, there is one radical proposal to grow nothing but ultra-fast growing trees on lunar or space settlement farms. Called ARBORCULTURE, this scheme would harvest the trees for pulp to feed vat-cultures of microorganisms which would transform this fodder into synthetic foods of every imaginable taste and texture. Someday that pseudo soylent green may well be the most efficient way to do farming on the space frontier.

Meanwhile, living BONSAI miniature trees can provide nostalgic ambience for the early pioneers. The Japanese have long cultivated the art of dwarfing trees for room decoration. By controlled pruning and fertilization, trees are trained, not bred, to grow in small pots into caricatures of older, bigger trees. Evergreens, leafy deciduous trees, vine and fruit-bearing varieties are all successfully miniaturized. Settlers can grace their private quarters with them. Room/area dividers can consist of shelf-rows of bonsais. Waist-high set-back platforms in passageways can be lined with them. Mini bonsai forests can adorn unused spaces. Pioneers needn't wait to bring along this quintessential human cultural symbiote. << MMM >>

MMM #52 - February 1992

On the Space Frontier, can there be any

FIRESIDE

around which to gather?

By Peter Kokh

Since time immemorial, ever since the taming of fire, humans have sought warmth, comfort, and company huddled around campfires and hearths. Even today, when a dwindling number of modern homes boast the luxury of a fireplace, nestling around the fire is something we all enjoy - when it is cold or damp, when we are out camping, on a clambake or a picnic in the park, or just out on the patio or in the back yard for a barbecue or marshmallow roast. And can any of us forget the bonfires after a high school homecoming football games?

While nowadays, such pleasures are scarcely everyday experiences, however infrequently enjoyed, the magic of the fire is so much a universally positive experience that it is still possible to ask: "can it be humanity if there is no campfire?"

In "FIRE DEPT." MMM # 51 DEC '91, we pointed out the very intolerability of open fire, controlled or not, in the very limited atmospherules of mini biospheres. But that is not the last gloomy word, for it only applies to fires in which the combustion products are smoke and toxic gasses.

In MMM # 40 NOV '90 "METHANE" we discussed the possibility of controlled burning of compost-pile derived methane to produce water vapor along with CO2 for plant nourishment. Such combustion will need to be confined to nitrogen-free chambers so as to avoid unwanted nitrogen oxide

byproducts. Could such a methane-oxygen fed flame in a glass- faced chamber serve as a fireplace substitute? Why not?

It should also be possible to devise a tightly confined hearth "substitute" that slowly fed together pure hydrogen and oxygen. If again the burning is confined to a nitrogen-free chamber, the only combustion product would be steam - pure water, which can then be used for drinking or other purposes. In effect, we are talking about a modified fuel cell, in which the 2H2 + O2 = 2H2O reaction is run somewhat faster, not so fast as to be explosive, but fast enough to sustain a flame, perhaps with a harmless enough additive (if one can be found!) to colorize the normally invisible H+O fire.

I'd be surprised if either such device now exists, with little market for them - down here. But out on the frontier, a flame-in-a-jar device might create enough symbolic warmth and cheer to become commonplace in settler homes on the Moon or Mars or elsewhere, in gathering spot lounges, even on long trips aboard spacecraft or surface roving coaches.

Why not tinker up such devices now? The methane version could not be used in draft-tight close quarters but a hydrogen hearth might sell to apartment dwellers, especially singles wanting the latest in trendy mood-setting gizmos. Just knowing that we could take such **"fire chamber"** with us, could make the prospects of life on the space frontier just a little less daunting, just a little more reassuring.
MMM

MMM #55 - May 1992

Beyond "Mole Hole City"

Our expectation of what a Lunar Outpost or Settlement might look like from the vantage point of a surface overlook has become one of a monotonously drab pattern of regolith mounds, the tell-tale sign of pressurized living space below. This "molehill-scape" is little relieved by its punctuation with occasional observation cupolas, exposed air locks, solar arrays and heliostats, peripheral tanks of volatiles, and other external warehousing. "Once you've seen one moonburg you will have seen them all." Not necessarily so! Eventually Lunan architects will rise to the challenge.

See below.

MOON ROOFS By Peter Kokh

Roofs on the Moon? - where it never rains or snows? Ah, but it does rain - a gentle slow micrometeorite mist, and a steady shower of cosmic rays, plus sudden 'cats and dogs' outbursts during solar flare episodes. While the characteristically imbricated (tile or shingle overlap) shedding features of terrestrial roofs would not be called for, the sheltering function of the 2-4 meters (6+ -13 feet) of shielding overburden above Lunar or Martian habitat space will be more than a little analogous to the familiar roof, a prehistoric heritage.

To the architect, the roof has traditionally been one of the most important opportunities for statement of style. To give some outstanding examples: the thatched English cottage, the terra cotta Spanish Tile roofs of the University of Colorado in Boulder, the green-patina copper roofs of many early urban skyscrapers, the onion domes of St. Basil's in Moscow's Red Square, the tailored French mansard, and the Pagoda.

It would be natural for future settlement architects in the employ of well-to-do façade conscious homeowners to turn to the shielding blanket as a clay for expression. And for those hired by companies seeking a striking design for their new headquarters building, to turn to lunar "roofs", alias shielding, as a medium of style.

Already, purely for the utilitarian reason of simple convenience, some outpost designers are specifying that their habitats be neatly sand-bagged. The advantage of placing the loose lunar regolith in bags should be obvious. Not only will it keep the construction site cleaner - and safer (from dangerous bulldozer module collisions) - it will allow the bag-tamed shielding to be easily removed in order to repair hull and joint leaks, to make structural modifications, and to exchange old, or attach new, expansion modules. Meanwhile, by this simple trick of bagging, the external appearance of the outpost is drastically altered. The 'lith-bagged outpost now looks like an on-surface installation rather than an under-surface one, its appearance and presence radically transformed.

An alternative to the bag or sack (which could be made on site from medium-performance lunar fiberglass fabric) would be sinter blocks made from compacted and lightly microwave-fused soil. By varying the size and shape of such blocks and the patterns in which they are stacked, distinctive igloo-like styles should be easily achieved.

Grecian Formula

It does not stop here. There is no cosmic law that states lunar shielding must be gray, or Martian shielding rust-hued. If desired, colorants can be added to the material itself, or glazed or even merely dusted on an exposed, rough surface.

In the early settlement, the availability of colorizers will not be great. On the Moon, Calcium Oxide, CaO, i.e. lime, made from highland soil will be a likely early favorite, probably cheaper than mare ilmenite-derived Titanium Dioxide, TiO, also white. Either way, "white-washing" Lunar settlement shielding mounds might early on become "politically correct", for they would make the settlement a conspicuous very bright spot on the Moon's surface, perhaps even outshining the crater Aristarchus. This would make Earthlubbers more conscious, and hopefully supportive, of their frontier-blazing brethren above - a cheap way to put any Moon town in the "limelight"!

More than empty vanity

By the simple addition of shaping or sculpting or colorizing, the shielding mound will become more than a visual disturbance of the surface. The 'lithscaper's or architect's touch can imbue the protective mound with design, unearthing the presence of the living and work space below and making the otherwise hidden structure visually present above the land-scape in an identifiable, pride-investing way.

This transformed self-image of the settlement may have real positive effects on the outlook, mood, and morale of the pioneers themselves. For it can be an early, easily won battle in a campaign to "humanize" the sterile barren alienness of their surroundings, thus contributing subtly to a sense of being "at home" in their adopted raw new world.

Economic opportunities

Indeed, outside of the occasional observation cupola, for most surface settlement habitat architects, the "roof" may be the principal opportunity for exterior public-side statement (other than any openings to also shielded public "middoor" spaces like pressurized roadways, passageways or squares etc.) But the opportunities for "roof"-styling will more than reward frontier architects. This market will also provide entrepreneurial openings for enterprising settlers to develop the additives, the tools, the equipment, the processes, for making such on-paper possibilities real off-the-shelf choices.

Bower Roofing

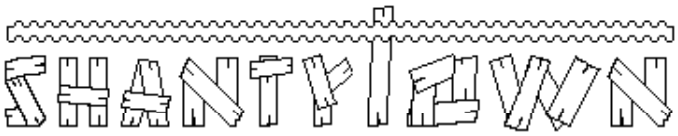
Nor need 'roof adornment' be an expensive luxury item. For it could also serve as an at least temporary 'banking' outlet for otherwise hard to recycle used building materials and other non-organic 'debris" - perhaps in shredded or gravelized form - and for various orphaned manufacturing and mining byproducts for which more suitable uses are not yet in sight. These are two stubborn categories

which contribute significantly to terrestrial landfills, yet receive little if any attention. Here we could take a page from the bowerbirds (8 species in Australia, 8 in New Guinea) who decorate the interiors and entrances of their nests with "found" objects of all sorts.

Settlement Signatures

Without attention to shielding style, it could well become a prevailing truism that once you've seen one surface frontier town, you will've seen them all. Given human nature and the slightest modicum of discretionary private and public funds, it is unlikely that such will be the case.

Distinctive 'lithscaping and "roofing" styles may become characteristic identifying trademarks, not only of individual structures, but of different lunar and Martian towns taken as a whole. And there will be economic incentive, and payback, for the small expense involved in the form of tourist interest in "local flavor". Long before any Lunar or Martian towns become large enough to begin to grow small high-rise "downtowns", they may become identified in the tourist mind by their individual mix of "roofing" styles. And all it will really take is a wee bit of imagination!



SHANTYTOWN

By Peter Kokh

We opened this issue with an IN FOCUS discussion of a current brash proposal to unilaterally open the Moon, or a large part of it, to homesteading. In all honesty, only space within a biosphere can be ripe for homesteading. In that sense, except for the obscenely wealthy, homesteading will not be an early way to open the space frontier. Some territory that is to be made "homestead-friendly" must be opened first.

Nonetheless, there will be at least temporary imbalances in the supply and demand for private residential turf on the frontier. Like it or not, there will be displaced persons, hard pressed to use their ingenuity to hustle up secured privacy (if not shelter) - within a constructed and maintained biosphere - using "found" cheap, if not free, discarded materials or by-products. There will be no outside ("outvac") shantytowns hugging settlement walls. But there may well be cyclical or even persistent economic dislocation and "quarterslessness" within the containing biospheres of the Lunar or Martian towns and their early boom-bust economies.

To hide from this eventuality like an ostrich is not appropriate planning behavior. Rather, recognizing that this unfortunate sideshow of what we like to think of as mainstream human life might well follow us out into our new adopted extra-terrestrial homelands, we ought to plan a gamut of strategies to deal with it. Barracks and dormitory space for newcomers, singles, estranged mates, and the elderly unwanted must be provided. The pace of public works outside the settlement, i.e. building new roads, outposts, supporting science excursions can all be speed up or slowed down as this labor pool grows or shrinks.

This said, there will still be those - hopefully only a few - who will be without proper personal quarters. But their numbers could rise in bad times faster than the public sector can make provision or adjustment for them. Within-the-walls temporary shantytown areas could be provided on an emergency basis to take up the slack.

Shantystuffs on the Space Frontier

As with shantytowns on Earth, the building materials of choice will be those that are free for the taking. Discarded skids and crates and tankage and other packing and packaging materials stockpiled for eventual recycling could be drawn down for this purpose. Indeed it might take little in the way of cost or effort to manufacture such materials in the first place with an eye to this potential reassignment or diversion of use, making them shanty-friendly so to speak.

Many items will be co-shipped as "packaging" to the Moon with the expense debited to the C.O.D. cost of the packed items. The idea of choosing, manufacturing, designing and/or processing such "packmates" so that they are capable of diverse reuse, is one we have mentioned before. For example, we could choose to ship things in copper, lead, or other strategic "lunar deficient" metals that can be cannibalized latter. We could choose to formulate packaging materials out of low molecular

weight solid hydrocarbons that can serve as chemical feed-stocks, or out of compostable molded materials rich in the micro-nutrients that lunar soil typically lacks, etc.

Manufacturing common shipping "tare" items so that they can also serve as easy-to-assemble shelter components, shouldn't be difficult. This process of adding extra features to make unrelated reuse simpler, easier, and cheaper is called "scarring". Given the hidden exorbitant cost of importing such co-shipments, it'd be foolish not to invest the relatively minor cost of scarring them to leverage the bootstrapping of the settlement economy. And when and if the need for "make-do" temporary housing disappears, these items could either be recycled or made available to entrepreneurs who can transform them into elements for durable and attractive housing.

Deliberate shantytowns and worse cases

While we might hope that the need for all this proves to be minimal, it is on the contrary possible that some space frontier settlements, in the asteroids for example, may even be designed totally as shantytowns through and through. They would be set up to serve some temporary purpose, then fold up gypsy style, to be set up afresh in some new location.

Other space frontier towns, confidently designed and constructed as "permanent", may suddenly find that the eco-nomic underpinnings of their survival have vanished through an evolution or revolution in technology perhaps, or through the opening of cheaper alternative sources of whatever they supply to the off-planet economy. If such a town has not moved early to diversify its exports, all or most of its inhabitants might suddenly become displaced. Without any alternate ways to hold on in "depression mode" until recovery measures can be realized, the need to shanty these people elsewhere may become urgent.

Differences from Earth

Hopefully, the minimal intra-biosphere shantytowns that do arise will not be totally dismal places. Even in the worst favellas surrounding our exploding third world mega-cities, it is possible to find pockets of art, design, and obvious pride of place. For it is not the materials that are used, but the care and imagination with which they are used that make such differences. The talents for blending composition, for artful juxtaposition, for cheerful accentuation with color, etc. etc. - these are talents that are rare. But they are also free.

Given likely high standards for settler recruits, these talents may be less uncommon on the space frontier. Shantytowns that arise out there, might prove welcome exceptions, exuding hope and promise, rather than despair and resignation.

Space Frontier communities will not be utopias - not in any social sense (despite careful preplanning for special challenges) nor in any materialistic sense. It will be a long, long time before life on the Moon, Mars, the asteroids, or in free space oases will be as sophisticated or genteel as in most any city on Earth. This frontier, like all those that have come along before, will be for those who thrive on the rough edges and cheerfully rise to the challenge of softening those edges, rather than those who need to find them already velvetized. And when this frontier opens, those who value luxury, refinement, and being up to date or ahead of the Joneses, will do best to stay behind on Earth. Space will be an opportunity to tame and create and overcome and contribute and sew, not soon an escape for those who would only reap and consume. MMM

MMM #56 - June 1992

The following article is not about Arts & Crafts per se, but is relevant.

HARBOR & TOWN
By Peter Kokh

Anyone who has read science fiction stories about the Moon or Mars has come across names like Port Roris, Port Heinlein, Port Lowell, Marsport, etcetera. It seems a natural way to name a space frontier town. Indeed, won't every such burg be a port? Not really! In the first "beachhead phase" of settlement,

we are likely to use vehicles like the Apollo era Lunar Excursion Module that could self-land, self-unload, and self-launch - no (space)port facilities needed, thank you!

But this sort of clean operation, efficient and necessary in opening virgin territory, also limits operations. Sooner or later the outpost/settlement-to-be will initiate genuine port functions. There'll be repair shops, fuel depots, landing beacons and paved pads, even smoothways for craft touching down with a residual horizontal velocity. There will be mobile cranes and specialized gantries. Trouble-shooters will service engines and doctor ailing CELSS air and water recycling systems. And a genuine space port will have been born.

To avoid expensive duplication, other outposts and towns that can be provisioned overland or by suborbital hoppers may chose not to develop full port facilities. They will have their self-service landing pads and smoothways, of course and they may see the occasional self-unloading freighter or chartered tourist craft, but nothing like the frequent, even scheduled cargo and passenger service of the "central' or "regional" spaceport. And this difference will translate into settlement lifestyles and cultures that are radically distinctive.

In contrast, one almost never hears the word "port" as part of the name of some fictional space settlement or O'Neill colony. Perhaps that is because the word naturally connotes to us the existence of some corresponding "hinterland" which the port serves. And our vision of space oases has been that each is a self-sufficient island unto itself.

How realistic is that? While each space settlement must have docking facilities, sooner or later one will offer special "port facilities" that will attract more traffic, making it a hub from which others are served by secondary craft. Indeed it seems to us more logical that one major spaceport or yard will emerge in the L5 co-orbital field, another at L4, and that a growing percentage of traffic will converge at these facilities, with cargo and passengers increasingly transshipped by barge and shuttle to "hinter-space" settlements.

If full service spaceports emerge on the frontier, what will they offer? In addition to the facilities and services already mentioned, port xity contractors will overhaul, rebuild, re-outfit, and reconfigure aging spacecraft and their systems. There will be a "junkyard" or salvage dealer, maybe even a grave-yard for obsolete craft (a museum in the making!) There will be warehousing for incoming and outgoing backlog buffers of cargo. There will be tank farms for liquid and gaseous volatile storage and chemical feedstocks. There will be a fuel depot for the many kinds of fuel likely to be used: liquid Hydrogen and Oxygen, Methane and Ammonia and Silane. There will be hoppers of powdered fuel: Iron and Aluminum and their enhanced performance powdered alloys. There will be containerized unloading and trans-shipment facilities.

In the nearby town will be the ship chandlers: dealers in ship supplies and equipment. Exporters of heavy equipment will find an advantage in a port xity manufacturing site. The bigger transshipment firms will headquarter here. Chemical, engineering, biospherics and electronics laboratories will sprout up to serve the growing list of port service contractors.

But the port town will also see the rise of import-export banks and trading houses, of "marine" insurance firms and trade law lawyers. Stock markets and futures markets could arise. Wholesalers will cater to the distribution market, fostering hinterland growth and that of the port xity with it.

Port xities may vie to become the "homeports" of various ships and whole merchant fleets. A sort of "Hanseatic League" of the major port xities in the Inner Solar System might arise to promote free trade, and regulations in their common interest, perhaps even footing the bill for a policing agency to counter piracy and hijacking. Such an alliance could be a forerunner of a loose System-wide political federation.

Port xities will tend to be socially and legally rather liberal in their mores, and noticeably more cosmopolitan in their ethnic and cultural diversity. In contrast, town founders wishing to try some great social experiment are likely to pick settlement sites off the beaten trade track.

Goods, both import and export, will be transshipped to and from the regional spaceport and hinterland or hinterspace communities. Much of this traffic will be containerized, using space barges, overland truck trains, and suborbital hoppers or slide landers, as the case may warrant. Passengers will travel to and from the spaceport xity by feeder surface coaches and suborbital craft or space-to-space shuttle taxis. Material novel-ties and cultural innovation will ripple outward from the space port centers to dependent outlying settlements.

Detachable holds of speculative trade vessels making circuit rounds between various settlements might be designed "snugline" fashion to slip into special airlocks and taxied or tugged to an in-xity market berth where they could unfold for business, self-contained import shops ready-to-go. Resident hawking agents would vie for the business of visiting trader ships not so equipped to do their own marketing. These trader craft or "circuiteers" would work to increase the amount of trade, thereby helping diversify the art-craft and manufacturing base of each xity on their routes. As a result, an ever greater percentage of frontier settlement economies would be involved with mutual trade as opposed to trade with the home planet. And an ever greater portion of that trade might be speculative rather than based on direct customer order.

This trade will be in specialty foods and delicacies, in special fibers and designer apparel, in chemical and organic feedstocks, in strategic raw materials and locally deficient volatiles, in furnishings and arts and craft accessories and gifts. An emporium, for the latest usually unavailable goods hot off the "traders", may determine by lottery who'll have a privilege to purchase items too few to match the demand. There will be barter and haggling. Dealers and galleries will take some speculatively imported art and craft items on consignment. Recognizable spacecraft parts may become fad "canvas" pieces for port artisans, much as old saws for country painters.

There may be trade in salvaged ship decor pieces and "architecturals" in demand by restaurants and hotels to provide space-maritime "atmosphere", or sought by individuals for their dens. Decommissioned spacecraft could find themselves resurrected as visitor centers, nightclubs, and roadside motels.

And what about visiting spacecraft personnel, the spacers and spacehands of lore? The port xity might offer more spacious and comfortable quarters in which to enjoy their liberty or "shore leave". There will be catering chapels and counselors, recreation clubs and sports facilities, and fast track intensive schooling. There will be medical clinics to treat postponed problems, and specially scheduled seminars to help them catch up on the latest technology in their field. The port will also be a place to receive waiting non-electronic mail.

Married spacehands may keep their families in the port xity, their children in its schools. The Moon and space settlements offering lunar standard 1/6th gravity will be the favored homeports for spacefarers, for the adjustment to and from zero-gravity will be much easier. Spacecraft providing artificial gravity are far likelier to offer the lower lunar standard as it is much less structurally taxing, and means either slower rates of rotation, a shorter radius or both. Few space-farers will call Earth home, or even Mars. "Sixthweight" rules! For the same reason, spacer guilds and guild halls are likely to be quartered in sixthweight ports. Here too will be the favored communal resting places for spacehands who do not prefer consignment of their remains to the so lonely depths of space.

And for the legally or behaviorally footloose there will be the usual spacefront dives and flophouses and dance halls: places where they can get quick fixes of whatever they found themselves lacking on the long journeys between ports. And there'll be unscrupulous town merchants seeking to trade worthless baubles for shore wages. Tattoo parlors? why not! But also prisons and brigs where needed.

Which brings us to the subject of salutary outlets for people who don't find themselves fitting in. The port xity will be a place for tired spacefolk to settle down. And the roster vacancies aboard visiting craft will be a siren for the town's restless. The port town's young will be drawn to the spaceport to watch the incoming and outgoing traffic, feeding their wanderlust. It is from their ranks preferentially, as opposed to the young of hinterland and hinterspace frontier towns and out-posts, that the next wave of volunteer settlers will come when some new world or worldlet is about to be opened.

Yet this dose of reality for would-be surface ports on the Moon and Mars! Increasingly, larger spacecraft, including all those using fixed booms rather than winchable tethers to provide artificial gravity in cruise mode, will be forever confined to space, unable to make planetfall.

Only zero-G space craft and shuttles will come down to the surface, plus the unique class of smaller circuit-making trader ships that are designed to separate in space into winch-tethered components for spin-up to sixthweight mode. [See the description of the aerobrake Earth-Moon ferry "Jules Verne" in "Lunar Over-flight TOURS" in MMM # 21, Dec '88, MMM Classics #3, and in the Transportation and Tourism Theme Issues.]

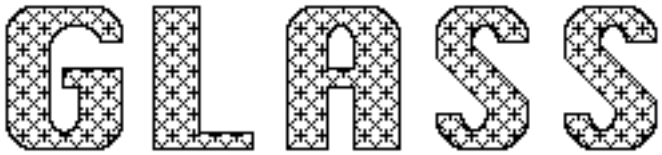
If this is so, then THE lunar spaceport may be a space depot in low-lunar-orbit, "LLO". Here the large fixed-configuration cargo and passenger ships will dock, their wares taken down or brought up by "lighters", passengers by shuttle taxis. Here in the environs of "Port Lunagate" will be the big shipyards

for big craft and their even larger successors. But, if this is only a transfer hub and not a population center, as seems the likelier eventuality (to this incorrigible planetary chauvinist) then the surface port xities that it serves will still hoard the bulk of the port-typical features discussed above.

Still, even if the really big ships never swoop down out of the starry lunar skies, the comings and goings of smaller craft will be the talk of the town. Reporters will interview inveterate old spacers, thirsty for the latest yarns. Newspapers will advertise the sudden manna of trader-brought goods. Restaurants will advertise the sudden availability of rare delicacies and savory delights. The port's bars will be enlivened by the company of the visiting spacefarers. Art and literature in the town will mirror this opening to the larger world. And among all the settlements on the frontier, those that are port xities will be the liveliest, most colorful, most memorable.

Yet for every Yin there must be a Yang. There will always be those who prefer the quieter, more relaxed, less quick-changing "best kept secrets" of hinterland and hinter-space towns in which to live, and raise their families. **MMM**

MMM #63 - March 1993



GLASS

By Peter Kokh

glass: a hard, brittle noncrystalline more or less transparent solid produced by fusion of mutually dissolved silica and silicates usually containing soda Na2O and lime CaO.

It is an inexact commonplace that glass is no more than fused sand, silica, silicon dioxide SiO2. In fact, while silica is almost always the major component, most commercial glasses contain, besides soda and lime, other dissolved oxides that give the product desirable properties. Alumina Al2O3 improves weathering and minimizes devitrification or crystallization. Borate B2O3 make the glass easier to work and lowers its rate of thermal expansion. Arsenic and antimony oxides help remove bubbles. Lead (PbO) contributes a high refractive index, easier working, and greater density.

Of the secondary and lesser ingredients commonly or sometimes used in modern glass making, Boron, Lead, Tin, Arsenic, Antimony, Selenium, Tellurium, Bismuth, Indium, Lithium, and Tungsten may not be economically producible on the Moon. Of these, we will most miss Boron and Lead.

Soda Borosilicate glass (Corning 7050) used for sealing is 76% silica, soda, and alumina - all producible in abundance. But it is 24% B203 which gives it an exotic Boron content of 7.44% or 1 part in 13.5.

Alkali lead glass (Corning 0010) used in lamp tubing is 92% silica, lime, soda, and potash but has a PbO content of 8% giving it an exotic lead content of 7.4% or 1 part in 13.5.

Pyrex (Corning 7740) is 85% silica + soda, but 13% B203 for an exotic Boron content of 4% or 1 part in 25.

Alkaline earth aluminosilicate high temperature glass (Corning 1720) is 95.5% silica, alumina, lime, soda, potash, and magnesia, but also 4.5% B203 for an exotic Boron content of 1.4% or 1 part in 72.

The most important formulation of all in terms of volume of production on Earth is everyday soda lime glass (Corning 0080) used for windows and lamps. It is 99.2% silica, soda, potash, lime, magnesia, and alumina - all readily producible on the Moon. It does, however, include 0.8% B203 which gives it an exotic Boron content of 0.25% or 1 part in 403. It is fortunate that the kind of glass we will need to make the most of, is also the one requiring the least foreign content.

We do have ready all-lunar choices.

Three such are:

A) SiO_2 69%, Na_2O 15.2%, CaO 7.4%, Al_2O_3 4.4%, K_2O 3.6%, Fe_2O_3 0.4%, MgO 0.4%.
B) SiO_2 66.7%, Na_2O 16.3%, Al_2O_3 13.2%, TiO_2 3.8%
C) SiO_2 69%, Na_2O 27%, Al_2O_3 4%.

The challenge for lunar glass makers is to make **a serviceable stable** of all-lunar glass formulations.
BOTTOM LINE: As far as the needs of glassmakers go, **sodium and potassium** are the most important secondary ingredients that regolith processing must produce (in addition to the abundant oxygen, silicon, calcium, aluminum, iron, magnesium, and titanium).
MMM

CERAMICS
By Peter Kokh

ce RAM ics: [Greek keramos - burn stuff]
Traditional: the **skill** of making things from **baked clay**.
Modern: the **science** of making things of **inorganic** and **nonmetallic** compounds.

On Earth we have long used ceramics for abrasives, for refractory liners and crucibles, for construction bricks, for floor and wall tiles, for architectural ornament, for tableware and storage urns, for flower pots, vases, and planters, for sinks and toilets, for knobs, handles, and giftware, for electrical insulators, and for many other uses. Lately Iranian-born Nadir Khalili [see MMM # 20 NOV '88 "Ceramic City"] has been experimenting with firing whole ceramic house modules, retaining walls, and other macro items. Quality manufactured ceramic raw materials such as alumina Al_2O_3 (carborundum), silica SiO_2, and zirconia ZrO_2 have opened the industrial use of ceramics: wear guides, valves, cutting tools, ball bearings, seals, gaskets, insulators, capacitors, memory cores, etc. Add to that new high-tech developments like non-oxide ceramics (carbides, nitrides, borides, and silicides), glass ceramics (e.g. correlle™), and ceramic metals or cermets for automotive and aerospace uses like turbine rotor blades and rocket nozzles.

It would be helpful to space pioneers if we could learn to make a similar range of products using lunar materials as a starting point. If so, we might even expand the traditional product lines, for example using ceramics to substitute as room trim "tilework" in place of "woodwork".

It might seem that the ancient potter's trade could not translate well to the Moon, a world without natural clays. Yet clays are but the water-weathered transformation products of virgin aluminosilicate feldspars in which the Moon is rich. We actually only need to add water to the proper powders in a coarse to fine ratio of 70:30.

One might think that any water-dependent technology would be an inappropriate choice for a water-parched world. But this too is no problem. The water of suspension from slip casting and the interparticle water from 'plastic' forming are quickly lost in the shrinkage of the shaped 'green body'. Pore water between the particles and physically bound water is removed as soon as the firing temperature passes 100° C. Above 600° C any lattice water trapped within the crystal structure is baked out. And finally, chemically bound hydrate water is purged above 1000° C. The end product is totally dry. The initial 'capital' endowment of H_2O is totally recoverable.

Available "Lunar" Formulations

For most low performance uses, the ceramic "raw" materials hardly need be refined. Alkaline (sodium, potassium) or alkaline earth (calcium or magnesium) aluminum silicates with widely varying formulae and structures will do nicely for bricks and tiles and planter trays and early tableware etc. As we become better able to control and select the ingredients we can make products that perform better, and look better. The production of alumina Al_2O_3, Silica SiO_2, Magnesia MgO, Titania TiO_2, and Zirconia ZrO_2 will be major goals in support of a more sophisticated ceramics industry. Once regolith gas scavenging is practiced, even carbides and nitrides should be within reach.

There are, however, some secondary ceramic ingredients that won't be economic options on the Moon. Arsenic, antimony, boron, lead, lithium, and zinc oxides find some application in ceramics and are not likely to be produced on the Moon. There unavailability will be felt, but not fatal.

Ceramic glasses deserve attention too. These are glass formulations allowed to partially crystallize (devitrify). This process proceeds around uniformly distributed crystallization nuclei, ordinarily small amounts of copper, silver, or gold, all apparently unobtainable on the Moon. However some metallic phosphates as well as Titania TiO2 will serve as lunar-producible nucleation catalysts. Correlle™ tableware is a ceramic glass. Greatly improved impact resistance is its trademark. It should be possible to manufacture something crudely similar in a maturing lunar settlement.

Practicing Lunar Arts and Crafts

Decorative ceramics will play a major role in lunar arts and crafts from the very beginning. Even at the outset, regolith batches gathered from diverse locations will produce products with distinctive features. Glazed ceramic items will provide welcome splashes of color – traditionally formulated 'paints' will be unavailable. Tile can replace woodwork and paneling and vinyl flooring. Given the unavailability of traditional jewelry metals, ceramic baubles will play a larger role in personal adornment. Given the likely taboo on withdrawing wood from the biosphere cycle, ceramics are likely to be part of a wood-substitution strategy for furniture. Ceramic toys will be considerably less expensive than plastic ones.

Industrial ceramicists have turned to dry powdered raw materials some time ago, while hobbyist and artisan potters and ceramicists continue to rely on clays. Those who wish to lay the foundations of lunar ceramics art and crafts cottage industries can start by turning to regolith-like powders.

[MMM #22 FEB '89 "First Souvenirs" >> MMM C3] MMM

color the Moon

"anything but gray"

COLOR THE MOON ANYTHING BUT GRAY

By Peter Kokh

"Blue moons" aside, the Moon is a very gray place. So much so that when Apollo astronauts stumbled on a small patch of regolith with a faint orange tint to it, there was a great deal of excitement on two worlds. If future lunar outpost crews and the settlers that eventually succeed them are to have any chance of keeping up their morale, they will need to see to it that their cozy pressurized safe havens against the magnificent gray desolation "outlocks" are literally alive with color.

For the initial outposts staffed by small scientific garrisons, the task will be easy. Their Made-on-Earth habitats will come vividly pre-decorated. But as settlement begins, based on the availability of shelter Made-on-Luna of lunar raw materials, colorization will have to be arranged locally using coloring agents derived from on site materials. This will take a great deal of forethought and prior experimentation.

The principal avenues for introducing color on the Moon as in Space Settlements built mostly of lunar materials are these: **1)** luxuriant green vegetation and colored foliage and flowers; **2)** naturally colored cotton and natural organic fabric dyes that do not stress water recycling systems; **3)** vitreous stains for coloring glass and glazing ceramics; **4)** inorganic "paints" that do not tie up precious carbon or nitrogen; finally **5)** colored "neon" lighting using noble gases scavenged from regolith-moving activities.

In this article we will deal with **3)** and **4)** above: inorganic chemical agents for decorating interior surfaces and to support a vigorous arts and crafts enterprise. The critical importance for keeping up settler spirits so that the populace can sustain overall high productivity, will demand that the processing of such agents be totally integrated, on a high priority basis, into the overall lunar industrialization strategy.

The bottom line is that those planning beneficiation suites and cascades needed to "stock up" the lunar industrial "pantry" with available "processed" elements, will have to pay as much attention to the production of coloring agents as to that of elements needed for metal alloys and glass and ceramic

additives. Happily our chemical engineers will find that many elements desirable for alloying can also support colorization.

Stained glass and vitreous ceramic glazes

Staining glass and applying colored glassy glazes to ceramic ware both have venerable, millennia-long histories. New coloring agents have been explored and experimented with to expand the choice of hues, tints, shades, brightness, opacity, transparency, and ease of workability.

Lunar pioneers will find many of the choices we now take for granted closed to them - those that involve chemical elements that we won't be able to produce economically on the Moon for a long time to come or must instead be expensively upported out of Earth's gravity well. Those lunar-supportable choices that remain will yield **a distinctive lunar palette**. The order in which these agents become available will clearly mark "**periods**" in lunar decor.[Elements not easily produced on the Moon shown in italics]

REDS Familiar agents that can't be produced on the Moon: lead chromate, cadmium sulfide, cadmium sulfo-selenide, and manganese copper. Lunar chemical engineers will be able to produce the chrome, the sulfur, and the manganese, but will not too soon nor too easily come up with the lead, cadmium, selenium or copper.

Fortunately, aluminum oxide mixed 4:1 with ferric oxide Fe_2O_3 produces an attractive red. While lunar iron is mostly ferrous, yielding FeO, the ferric oxide can be prepared by controlled rusting of native iron fines from the regolith. A spinel, $FeO.Fe_2O_3$, produces a darker red. A tomato red can be prepared from Uranium oxide which can likely be found with known Thorium deposits

PINKS Lead chromate and chrome tin pinks are out - little or no lead or tin. Chromium-zirconium is a possible substitute. A manganese-alumina pink and a chromium-alumina pinkish red are other choices. Eventually, cobalt-magnesium combinations might produce a pink to lilac range

ORANGES Unsupportable lunar options are Uranium-cadmium and chromium-iron-zinc. Glazers may have to blend available reds and yellows.

YELLOWS The list of closed options is long: lead chromate, lead nitrate, zinc oxide, antimony oxide, red lead, potassium antimoniate, vanadium-tin. Instead colorizers will have to play with vanadium-zirconium and titanium-iron oxide preparations.

BROWNS Unavailable will be the orange brown of copper-based $CuO.Al_2O_3$ and the reddish brown of zinc-based $ZnO.Fe_2O_3$. But in stock should be the reddish brown of iron chromate $FeO.Cr_2O_3$, the Indian red-brown of magnesium-iron oxide $MgO.Fe_2O_3$, and the red-brown manganese titanate $MnTiO_4$.

GREENS Out are chromium-beryllium, lead chromate, copper, and copper-vanadium preparations now in use. A blend of yellowing vanadium and bluing zircon in the presence of sodium fluoride (if fluorine can be produced, a difficult but high industrial priority) is an option. Praseodymium (from KREEP deposits) phosphate with a calcium fluoride additive is another. The deep emerald green of chromium oxide may be the standby. This could be blended with available yellows and blues to produce neighboring tints.

BLUES My favorite color. "If we can't do blue, I ain't goin!" Many blue ceramic stains use zinc oxide, barium carbonate, tin oxide, and copper phosphates. Fortunately cobalt aluminate yields a matte blue, and cobalt silicates and oxides produce mazarine blue, royal blue, flow blue, and willow blue. A titania-alumina blue, $TiO_2.Al_2O_3$, with a corundum structure is a possibility but it is difficult to prepare by synthesis as opposed to starting with Ti-rich bauxite. Other choices include a vanadium-zirconia blue and a silica-zirconia-vanadia-sodium fluoride system of blues, turquoises and greens. I can go!

WHITES Commonly used tin and antimony oxides will likely be unavailable. Instead, titanium dioxide, zirconium dioxide, and zirconium silicate seem the way to go.

BLACKS Blacks have always been the most difficult stains to produce as there are few truly black inorganic agents. Instead we are left to blend semi-blacks with noticeable green, blue, or brown casts to them in hopes of neutralizing those tints and being left with apparent true black. Given the narrowed list of preparations available on the Moon for blending, coming up with a satisfying black will be especially difficult.

COMPLICATIONS Making everything harder is the fact that the choice of flux affects the color outcome. Lead fluxes will be unavailable. While there has been considerable success in preparing lead-free glazes

and fluxes on Earth, many of the substitute preparations rely on other elements hard to come by on the Moon such as zinc. Glazes based on feldspar (aluminosilicates of potassium, sodium, and calcium), alkalis (Na2O, K2O), alkaline earths (calcium and magnesium) with borax (hydrated sodium borate) will work. The trick is to find the boron. It seems absent in the crust but should be in the mantle. Central peaks of large craters may include upthrusts of mantle material and will be worth prospecting for this and other elements. Boron is a frequent major addition to many glass formulas as well.

Lead and boron make the best fluxes and if neither is available we may need to experiment with sodium, potassium, or NaK compounds. "Waterglass," a hydrated sodium silicate and the only known inorganic adhesive is a possibility and it is on the must-produce list anyway.

None of the needed experimentation need wait upon our return to the Moon. Would-be contributors to a pretested distinctively lunar palette of glass-staining and ceramic color-glazing preparations need only religiously exclude at every step any of the coloring compounds based on lunar-scarce elements and concentrate on those likely to be produced in plausible beneficiation and chemical processing suites.

This is, however, a task that can occupy many people over long periods. They might establish a network and share the results of their trials and errors. Art styles that preview lunar settlement art will result, helping to promote the opening of the frontier by making its visualization more concrete and vivid. Future lunar settlers will be much in their debt for contributing greatly to their way of life.

Stained glass

As to working with stained glass, once we are able to produce it in a variety of colors, we face another problem. The individual pane-cells that go into a stained glass mosaic piece are usually held together by lead caning. We'll either need a pliable and malleable lunar-sourceable substitute (a stabilized sodium-potassium alloy?) or we will have to bypass the problem. One approach may be to cement the individual pieces on a host glass pane using a waterglass type adhesive. If we want stained art glass dividers and Tiffany type lamp shades we will have to literally get the lead out, one way or the other.

Oxide pigments for waterglass suspension "paints"

Painting, in one form or another, has been practiced from prehistoric times. Lunar paints will return the art to exclusive reliance on inorganic oxide pigments, greatly reducing the available choices and again producing a distinctively lunar palette for home decor, art and craft use, and painting in general. Forget today's vivid coal-tar derived organic pigments. Forget the alkyd, oil, acrylic, and latex suspensions. Forget the organic solvents. All of these rely almost exclusively on organic materials, and in a lunar or space settlement environment would mean permanent withdrawals of carbon and nitrogen from the biosphere cycle, demanding replacements at high cost. Until the day carbon and nitrogen can be produced locally as cheaply as inorganic substitutes, formulators of lunar paints will have to rely on something quite different.

Perhaps the best candidate for a suspension medium is the only known inorganic adhesive, waterglass, a hydrated sodium silicate ranging in formula from Na2O.3.75SiO2 to 2 Na2O.SiO2 and as white powders or viscous-to-fluid liquids. MMM suggests preparing paints which are suspensions of lunar-sourceable inorganic oxides in waterglass. Unprocessed fine-sifted regolith dust can be added for graying the hues. Flecks of aluminum can provide a silver, and particles of FeS2, Pyrite (fools' gold), can produce a gold.

What about a canvas? That's an easy one. Try painting on glass. Flip the finished piece over or lay on another pane to present a protected face. For large expanse painting - like walls - we could try titanium dioxide or calcium oxide (lime) waterglass based naturally flat whitewashes. While experimentation with lunar-repeatable glass staining or ceramic color glazing will beyond those without access to a good chemical lab and considerable experience, trying out lunar type paints should be something quite a few of us could try.

We hope one or more readers will be inspired to take the plunge and thus advance us one big notch further towards a livable lunar frontier. Pioneers in lunar appropriate colorization, whether they ever set foot on the Moon or not, will have a special place in Lunar Settlement Prehistory.

BOTTOM LINE: to supply those who would add a healthy dash of color to lunar existence, processors, in addition to supplying elements present in abundance, must also isolate **chromium**, **cobalt**, **potassium**, **sodium**, **sulfur, vanadium**, and **zirconium**. **MMM**

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SULFUR-BASED CONSTRUCTION MATERIALS

The Jekyl-side of a Moon-available element

By Peter Kokh

Sulfur is to oxygen as silicon is to carbon - i.e. one notch up in the same valence column in the periodic table of elements. It comes in several allotropic forms: tetrahedral, monoclinic, and rhombic crystals, and in an amorphous quasi-plastic form as well. Sulfur is non-toxic, and non-irritating to the skin. It has many industrial, metallurgical, medicinal, and agricultural uses. There is as much as one part per thousand sulfur in the Lunar regolith as Pyrite, fool's gold FeS2. Pyriting steel surfaces would give them a decorative brassy color.

In 1978, oil-rich Dubai began using the 100,000 tons of sulfur removed from its oil at the refineries each year to make '**sulfur-concrete' blocks** for housing construction. Sulfur, hot-impregnated into the block, serves as a densifying impervious binder.1 Surprisingly, this use was nothing new.

Chapter 14: Sulfur Containing Materials, pp 308-320 in SULFUR, ENERGY, & ENVIRONMENT, by Beat Meyer, (Elsevier Scientific Publishing Co, New York, 1977. ISBN 0-444-41595-5) lists a slew of patents for sulfur-concretes, sulfur-foam, sulfur-ceramics, and S-based adhesives and seal-ants. Some have potential application to Lunar construction needs in lieu of organic materials or alongside other inorganics.

Sulfur Concrete: impregnated into concrete at 125°C (257°F), 8-13% sulfur addition increases tensile strength to 700 bar or more, 6-10 times original value. Sulfur concrete is used worldwide, e.g. in sewer pipes. On the Moon, sulfur concrete may complement fiberglass reinforced concrete.

Sulfur-bonded aggregates: Sulfur has been mixed with clay, glass, and quartz to make architectural ornamentation that can be colored; with sand, and gravel for street pavement; with sand to be cast into floor slabs and side-walk blocks; with 60% Portland cement to make imitation china; and with marble dust to make artificial stone.

Sulfur foam: Sulfur has been foamed by itself, as a poly-sulfide, and as an additive to polystyrene and poly-methane foams. These have a density of from 5-60 lbs/ft3.and have been tested as insulation boards and even as ICBM silo liners. It is the pure or almost pure sulfur foams (with little hydrocarbon content) that are of interest for lunar application.

Sulfur Ceramics Vacuum impregnation of tiles and ceramics yields products with greatly improved resistance to moisture, corrosion, and temperature shock.

Sulfur and sulfur-added Adhesives and Sealants bond most types of materials well. These partially-explored and test-proven uses of Sulfur-based construction materials give enterprising encouragement to would-be Lunar developers. A solid foundation for further R&D. .

MMM

1 BUILDING FOR TOMORROW: Putting Waste to Work, by Martin Pawley, Sierra Club Books, San Francisco, 1982, ISBN 0-87156-324X. Page 8

MOON WOOD

Devil Magic with Yellow Brimstone Stuff?

By Peter Kokh

Sulfur Composites and the Unexplored Frontier

Of all the work already done exploring sulfur-based construction materials, what has really grabbed our attention is the fact that sulfur is already in use[1] as a matrix for wood, paper, felt, and fabric fibers, into mats of which it is hot-impregnated. To the resulting composite sulfur brings density and imperviousness, tensile strength and durability.

fi Could we not similarly impregnate fiberglass fabrics and mats with hot sulfur[2]? Could such lunar-sourced and fabricated composites be a significantly cheaper option for lunar manufacturers of items traditionally made of wood or plastic? Would they fill a different end-product niche than SSI's Fiberglass-Glass Composites (Glax™)? We suspect that the answer to all these questions is "yes".

Yet we worry, not knowing, that all such composites might be vulnerable to corrosives or fire, and liable to produce the nauseous H2S rotten egg gas hydrogen sulfide, or the industrially and chemically useful but otherwise unwelcome H2SO4 hydrosulfuric acid. That would be a problem. In lunar and space settlements noxious, toxic, corrosive, and flammable materials must be highly controlled if permitted at all. Sulfur composite products, then, may need some sort of stabilization or surface armor coating. Answers may already exist.

Let us assume that if such concerns are real, they are not insuperable, and that **FSC** (Fiberglass Sulfur Composite) alias **FRS** (Fiberglass-Reinforced Sulfur) alias **SIF** (Sulfur-Impregnated Fiberglass) is an appropriate Lunar-producible material that may be useful as a substitute for traditional organic materials that it would much be too expensive for the settlement to "withdraw" from its closed loop mini biosphere.

While such a composite would be rather dense, it ought to be softer than any all-glass composite. Could it be formulated to have a workability similar to wood? Sawable, drillable, shapeable, sandable, carveable? While that may be too much to ask, any of these qualities would be an asset. An SIF wood substitute might be given trade names like Moonwood,™, Xanthite™ [pronounce Zanthite], Xanthic™, Xanthyl™ [from Greek xanqos - yellow], or Carpentrite™.

Plyxanth™ and its uses

We should be able to manufacture plyboards of the stuff. No glue would be needed to bond the plies. Enough heat, or a skimcoat of hot liquid sulfur, or some other sulfur-based adhesive would do the self-bonding trick.

For use as a surface material, the top finish ply could, if desired, be textured in the manufacturing process. It could also be colored with sulfur-soluble dyes if these were not organic coal tar derivatives which on the Moon would have to be synthesized by other routes from agriculturally produced chemical feedstocks. But their use for this purpose would involve permanent withdrawals of the involved hydrogen, nitrogen, and carbon from the biosphere (the oxygen and sulfur being no problem). But up to 5% available metal oxides have also been used successfully[3] to modify the final color from brown hues to orange. Greens and grayed yellows should also be easy to affect. So our proposed plyboard might not have to retain its natural yellow. In addition, we might subtly affect the finish hue by staining the fiberglass component [see "Color the Moon" in MMM #63]. Finally, we could give the surface other colors with paints of metal oxides in a waterglass suspension doubling as a protective armor coat.

As a substrate material, SIF plysheet could serve as a general construction 'carpentry' material as well as panel to be covered with fragile materials like foils, fiberglass fabrics, and fiberglass wall carpets used for sound-deadening. It may serve too as a suitable backerboard for ceramic tiles, even in wet area applications like showers and sink backsplashes.

Perhaps thinner corrugated sandwich SIF boards could be fabricated to serve as a lunar cardboard substitute out of which to make boxes, packing separators etc. SIF 'cardboard' might also work as a canvas for painters using metal oxide waterglass suspension paints. And if we can find a workable lunar-sourced paper substitute for the pages, this lower density SIF board might do as book "hard cover" material.

Other Uses of Moonwood™ or Xanthite™

SIF Moonwood™ could be a welcome new option in furniture making, for interior framewall systems (both studs and panels), for room trim (Xanthmill™? or Xanthwork™?), and for arts and crafts applications - especially if it is an easier material to work, carve, saw, drill, shape, and glue than the all-glass composites. Even if nailing and screwing are out, peg joints can be set with a cement of hot sulfur which is already in use as an anchoring cement to set iron posts in concrete.

Dense, impervious oxide-tinted formulations of this material could be fabricated as paving tiles, drain tiles, and basins, even tanks and hulls not exposed to the sun. Since it can be more easily fabricated on site than glass composites, SIF might be the material of choice for making very large planter beds, pools for swimming or fountains, drainage basins, and for similar large size custom-fabricated applications, either as the principal material or as a coating for a construct of other Made on Luna materials. It is perfect for on-the-spot repairs of leaking pipes and other water containers.

Where you come in

Perhaps this speculation is naive and simplistic, based as it is on a layman's knowledge lacking real familiarity with whatever manufacturing or performance limitations such materials may exhibit. MMM would welcome comments from those more knowledgeable. And we especially wish to encourage 'Young Turk' experiments by those who have the [access to the] equipment necessary to perform them.

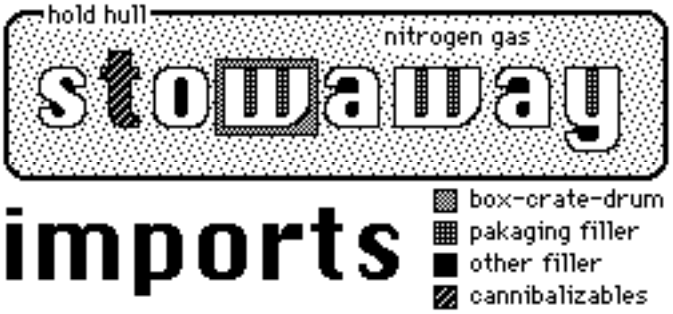
Let's hear from you! MMM

References:

1 Meyers, op. cit. [Sulfur article preceding), p. 314.

2 Pawley, op. cit. [Sulfur article preceding], p. 9. A house made of newsprint core beams and newsprint panels was coated with a thin layer of sulfur and glass fiber to retard corrosion.

3 Meyers, op. cit. p. 318.



STOWAWAY IMPORTS

Using Hitchhiker and Bonus Imports to Hasten Settlement Self-Sufficiency

By Peter Kokh

Three Opportunities for strategic substitutions

There are three basic categories of opportunity to ship to the Moon badly needed "Lunar deficient elements" - strategic metals and volatile feedstocks - virtually **"for free"**. That is,

- The freight is actually being billed to other
- Import items, and would still be levied …
- Whether these opportunities are seized or not.

These are **(1)** containers and packaging materials or "tare stuffs" used to ship the principal items on the Manifest; **(2)** parts and components of imported items that would normally be made of elements in which the Moon is already well endowed [see the end of the "MUS/cle" article just above]; and **(3)** cannibalizable parts of the shipping vehicle or of its outfitting that either are not needed for the return

trip to Earth and could be replaced there, or which could be replaced with Lunar substitutes upon arrival on the Moon.

In all three cases, play in the "substitution game" is initiated on Earth. In the second and third case, there is a "counter" or "complementary" substitution made on the Moon. In the second case, this match move could be delayed for some time, the endowment being "banked" in the imported item as it is being used. [see previous article].

What substitutes for what?

On the one hand, the stuffs, parts, and components in question are those that would normally be made of elements for which the settlement has no need, namely, those which can be produced economically on location: oxygen, silicon, iron, aluminum, and titanium especially. The operative rally cry here is **"No Coals to Newcastle"** i.e. no ice for the Eskimos, no sand for the Saudis, etc. Shipping or co-shipping items so formulated constitutes no less than a criminally wasted opportunity to bootstrap industrial diversification.

Instead, we want to substitute other metals such as copper, zinc, lead, gold, silver, platinum, etc., or alloys rich in them such as duralumin, monel, bronze, brass, pewter, etc. Where such substitution is impractical, an alternate option is to preferentially use stainless steel or any of several other industrially desirable steel or aluminum alloys for which the alloying ingredients cannot be easily produced on the Moon.

Some constraints apply: the substitute metals must be formulated to perform adequately, and must not involve added weight. The trick is to avoid paying a weight penalty in substituting heavier metals for lighter ones by using less of them or by other tricks. If this pitfall is avoided, substitution costs aside, the actual transportation costs will be nil, charged as "overhead" on the bill for the principal shipment, whether the helpful endowing substitution is made or not.

As to oxygen, it is a principal component - often in the 50% range - of paper, cardboard, wood, plastics, styrofoam, and other materials often used as containers, packaging wrap, separators, and fill. Instead, it will be to the settlement's great advantage to substitute tare stuffs formulated from low polymer hydrocarbons that can easily be broken down into the constituent hydrogen and carbon - both very precious on the Moon - or used as chemical feedstocks in Lunar industries.

Other substitution possibilities include soaps and waxes and friable or biodegradable compositions rich in those agricultural micro-nutrients or fertilizers in which lunar regolith soils are impoverished. A stuffing and cavity-filler option that could sometimes be appropriate would be to use air- or freeze-dried luxury food items (to be reconstituted with water made with lunar oxygen) (e.g. fruit, milk, eggs, spices) not likely to be produced in the early stages of lunar agriculture and which would add much to special occasion menus and to over all morale and morale-dependent productivity. Such items (along with human wastes from arriving ships) will be much valued accumulating additions to the local biosphere.

Oxygen is also an unnecessary 21% of the Earth air with which cargo holds would normally be pressurized. Instead we could use pure Nitrogen, the extra 21% most appreciated on the Moon. For the return trip, the holds could be pressurized with Lunar Oxygen, either alone or buffered with Argon and Neon scavenged from the regolith by modest heating.

As every gram of pest potentially takes the place of many pounds or tons or food or product in the food chain, pressurizing holds filled with seeds and seedlings with pure Nitrogen, heated to 65° C (150° F) or so could be doubly important. Attention to a whole host of "little" opportunities like this could make the difference to settler self-sufficiency. Lost nickels and dimes add up quickly to real lost dollars.

"Changing the Rules":

Cannibalizing Outbound Vehicle Equipment

Passenger and Cargo ships alike bound for the Moon will contain many components, parts, and items of outfitting that are either not strictly needed for the trip home, or which could be replaced by Made-on-Luna fabrications for the trip back to Earth. If these ships are deliberately designed and outfitted for cannibalization, the cost of off-the-shelf assembly-line-item reoutfitting per flight could actually be less than the customary one-time individually customized outfitting that has become NASA's one-trick pony.

Certainly this will involve a major paradigm shift for those spacecraft designers and their cheering sections who currently are aware of only two sacred cow choices: Expend-able and Reusable - neither of which are anywhere near appropriate for opening the frontier. These two are like Thesis and Antithesis. The Synthesis is to send ship[parts] one way to the frontier for "Reassignment" there. So add Reassignable to Expendable and Reusable. It's a frontier door-buster.

Until industries are in place to fabricate replacement parts, only those items not actually needed for the trip home can be removed upon Moonfall for cannibalization. Gradually, other parts can be replaced on the spot with prepared Lunar fabrications. We'd be removing items made of Lunar deficient metals and alloys and volatiles and replacing them with items made of Lunar abundant materials (iron, aluminum, glass, glax, ceramics etc.) from basic settler industries.

What type items are we talking about? Nonstructural (akin to non-load-bearing) interior partitions; floor, ceiling, and wall panels; interior doors and trim; fuel tanks, eventually even cargo holds, platforms, exterior booms and beams etc.

For ships carrying settler recruits one way and returning empty except for crew, the list includes the partitions and decor panels of individual quarters, dishes, cutlery, and food preparation equipment, cabin furniture and furnishings, entertainment equipment and libraries, beds or berths, bedding and towels, sinks and toilets, even snap-in/snap-out copper wiring harnesses. If you use your imagination, the list gets surprisingly long and potentially all-inclusive.

Indeed, we'd have the choice of either stripping the passenger cabin or removing it wholesale to be mated to a new chassis and used as a surface coach! Or perhaps covered with regolith and used as a construction shack in the field! Even here, we'd want to have as much as possible of the cabin and its original outfitting made of Lunar deficient materials for gradual retrofitting replacement with local fabrications allowing the original materials eventually to be cannibalized.

Best of all, the fuel expended in getting all this accessory equipment to the Moon gets billed as part of the passenger fare or cargo freight whether any of this stuff is removed or not. So IF we designed the craft and its outfitting for this kind of wholesale reoutfitting each trip, using "knock-down" assembly techniques to make the job a breeze, the settlement can get all this "loot" virtually for free.

If you think about it, the whole concept of Reassign-ability absolutely shatters up till now universally accepted fuel to payload ratios. Potentially, everything except fuel becomes payload. And that changes the economics of opening the space frontier quite independently of whether or how soon or how much we realize cheaper access to Earth orbit.

Earthside Entrepreneurial Opportunities

Formulating and fabricating items out of elements scarce on the Moon instead of those abundant there may or may not lead to terrestrial applications. That depends largely upon entrepreneurial imagination and market testing. Making tare items (containers and packaging etc.) of alternate materials should certainly lead to marketable products for consumers who are becoming increasingly sensitive to the environmental impact of everything they use. The idea of making things to be reassigned and/or cannibalized is sure to have applications both in the consumer products field and in the continued opening of terrestrial frontiers like Antarctica. Imagination is the only limit.

The Bottom Line

To a lunar settlement, every pound or kilogram of imports or co-imports "along for the ride" made of elements economically producible on site "costs" a pound or kilogram of dearly needed "lunar deficients", hard-to-do-without elements not locally producible, that could have been imported instead for the same import bucks. This is the kind of opportunity that a for-profit operation seeking to open the frontier would eagerly seize upon. It is also the kind of opportunity that deficit-jaded government operations routinely shrug off.

Taking the pains to reformulate these potentially free "stowaway" imports will slowly but inexorably build up substantial endowments on the settlement site that will go a long way towards removing the severe industrial handicaps under which the pioneers must otherwise operate - and all virtually free of real added cost. The fuel expended to get these items there, reformulated or not, is in effect a hidden import tax. As this tax must be paid anyway, it'd be unforgivable not to use the bootstrap opportunities involved. MMM

To minimize the mass fraction of bulb and other light system components that must be imported, careful, even novel choices might be in order.

By Peter Kokh

I have never seen a reference that gives any indication that anyone else has ever considered the unwelcome problems posed in the continued importation to a lunar settlement of lightweight but bulky and fragile (therefore over-packaged) light bulbs and tubes. It would seem to me that the lunar manufacture, or at least final assembly, of such devices would be somewhere in the upper third of the list of priorities. The problem is that each of the growing number of diverse lighting bulbs and tubes incorporates some elements not native to the Moon in economically producible abundances.

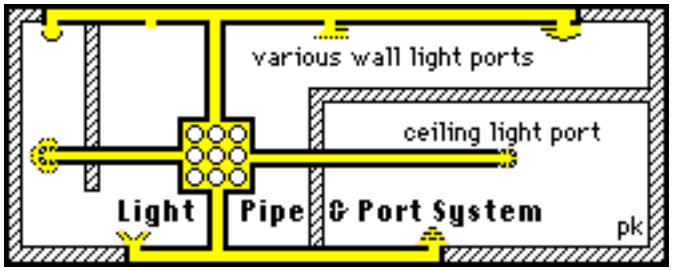
Our familiar everyday **incandescent** light bulb is quite reliant on tungsten wires and filaments for which there is NO practical substitute. The amount of tungsten involved is, however, trivial, and could be affordably imported, preformed and ready to be assembled with Made-on-Luna glass bulbs and mounts. The screw-in or bayonet base can be aluminum with a minimal amount of brass needed for the contact points. The evacuated bulb can be filled with lunar Argon gas. Available coatings include phosphorus produced from known regolith KREEP deposits. Light bulb manufacture is among the most highly automated, with about a dozen people needed to make most of the incandescent bulbs used in the U.S. (per manufac-turer). Lunar production would not hog precious personpower.

High intensity halogen lights would necessitate the importing of either bromine, iodine, or fluorine gas along with tungsten filament. To save energy, other light bulb types and fluorescent tubes may be are preferable. But energy savings must be weighed against the gross mass of ingredient materials required that must be imported on an ongoing basis.

Early **fluorescent** tubes were filled with mercury gas and had UV-sensitive phosphorescent coatings of calcium, magnesium, or cadmium tungstate; zinc, calcium, or cadmium silicates; zinc sulfide; borates of zinc or cadmium; cadmium phosphate; finally calcium phosphate. Only the last would be a good choice for lunar manufacture.

In addition to the phosphor used, a relatively small amount of activator to facilitate its excitation is necessary: among these copper, silver, antimony, and bismuth are not lunar-appropriate; thallium may be so someday; and only manganese will be available locally any time soon. However, the small amounts needed should not be a problem to import. Greater challenges are the sophisticated process needed to produce the coating in 2-8m size and the organic binding material needed to coat it on the glass.

The recent development of **Light Pipe** technology suggests an altogether different approach to indoor lighting on the Moon. Instead of a multiplicity of individual lamps and light fixtures, a network of Light Pipes whose rib-faceted inner surfaces channel light without appreciable loss to locations remote to the light source could be built into each building, ending in appropriately spaced and located Light Ports. A central bank of efficient high-pressure lunar-appropriate sodium vapor lights could feed the network during nightspan, sunlight feeding it by dayspan, to form an integrated light delivery system, part of the architect's design chores. Delivery Light Ports could be concealed behind cove moldings to produce ambient ceiling illumination or end in wall ports that could be mechanically variably shuttered or dimmed from full "off" to full "on". If the reverse side of such shutters were mirrored, the 'refused' light would just go elsewhere and not be lost. A low voltage feedback loop could match supply, the number of central bank lamps "on", to the number of Light Ports open.



Wall and Ceiling Light Ports could then be fitted with any of a growing choice of consumer purchased and artist designed decorative plain, etched, or stained glass; or pierced metal diffusers; or fiberglass fabric shades. Such a system might allow the number of types of bulbs that need to be manufactured to be minimized, allow the use of the most efficient bulb types, appreciably reduce the amount of wiring needed, and still allow wide decorator choices. MMM

Letting the Right Hand Know

What the Left Hand is [by]doing

ENCYCLOBIN INC.

"A question of not wasting spent personpower"

By Peter Kokh

Making the most of energy and personnel will be very important anywhere on the space frontier where existence must be eked out in barren surroundings untransformed by eons of living predecessors. Support from Earth will be dear, no matter to what cost/per kilogram launch expenses fall. To waste no import crumb, to put to best use every scheduled productive hour, to get the most out of the talents of available personnel, it will be vitally important to keep track of things of which we are by habit oblivious in our terrestrial "business as usual". The settlement with the cavalier attitude towards loose ends will fail. The one that ties up those loose ends in bonus bouquets will thrive.

What is needed is a hyper-organized or multi-dimensional matrix type data base in which the settlement can keep track of every gram of reject and byproduct and waste in every category of material from all its industries and enterprises. Any enterprise would be able to access this resource bank and find out which of its needs is available, where, and for how much. Any discarded material has already had work done on it - if only the sorting, and putting that expended work to profitable use, instead of losing it in a default waste regime, will enhance by that much the net productivity of the community.

Relatively unprocessed tailings, partially processed slag, fully processed reject material; solids, liquids, gasses, even waste heat: these are all things worth keeping track of if one wants a leg up on the formidable odds against success of the settlement. Such items can then be banked where produced or moved along specific routing channels to some surplus commodities exchange warehouse. Purchases can be direct two party affairs or mediated by the utility as a special broker.

Using "partially cycled" or "precycled" items makes as much economic sense as using "recycled" ones. It keeps down the cost of manufacturing new goods, can be the source of new enterprises, and helps minimize the material impact upon, and disturbance of, the host terrain, thereby stretching resources that future generations will need as well.

An "Encyclobin" Utility would be a publicly regulated enterprise to keep track of all such items and charged with facilitating their fuller use as potential resources. By keeping track of byproducts unwanted by each producer, it will help inform the "right hand" of what the "left hand" is "by-doing" so to speak. Personal talents, expertise, and experience ought also to be listed for help in putting together

teams for new projects. Encyclobin would serve as a finder service, for which there would be a fee to help maintain and grow the system.

The **University** might run such a system to best categorize everything, trace potential connections, and suggest novel applications to enterprise. Waste not, want not! MMM

MMM #67 - July 1993

Settlers can't live by bread alone!
Farm "Pods" can churn out many other needed products

Relevant READINGS FROM Back issues of MMM

[included in MMM Classics #1] MMM #4 APR 87 p9 "Paper Chase", Peter Kokh
[included in MMM Classics #2] MMM #13 MAR 88 p8 "Apparel"
MMM #15 MAY 88 p5 "Threads", Aleta Jackson
[included in MMM Classics #4] MMM #40 NOV 90 p6 "METHANE", Peter Kokh
[included in MMM Classics #5] MMM #48 SEP '91 p8 "Naturally Colored Cotton", P. Kokh
[included in MMM Classics #6] MMM #55 MAY 92 p9 "Agri-Garments", Michael Thomas

INTRODUCTION

To date, Experimental Lunar Agriculture has concentrated on the production of fresh vegetables needing little or no processing (lettuce and salad stuffs) and on such staples as the potato (Ted Tibbits at the University of Wisconsin Biotron) and wheat and soybeans (Bill Easterwood at EPCOT Center).

But this is just a start. Not only will Lunar farm pods eventually produce far more food crops than those experimented upon to date, but it will be called upon to grow crops for quite other purposes. Fiber for clothing, toweling, and furnishings will be especially important. Household preparations, cosmetics, pharmaceuticals, and chemical feedstocks will take their place as well in the agricultural sector of the settlement economy. Anything organic that consists in major fraction of lunar-sourceable oxygen is potentially cheaper to grow on site rather than import from Earth. Different frontier communities will have their specialties, and trade between them should be brisk.

As an industrial activity, lunar agriculture will start as "small potatoes" yielding "produce" only that has to be "home made" into meals. Farm pods will be highly automated, saving labor for mining, materials processing and manufacturing of building materials and energy stuffs for export as well as for use on the frontier to defray imports.

Food processing, which in America employs far more people than does food growing, will be insignificant at first, starting up essentially as part-time after hours cottage industry.

As the number of people on the frontier grows, economies of scale in other areas of industrial activity will gradually make it possible to justify a growing primary employment in the food industry. Condiments, sauces, gravies, preserves, baked goods, precooked packaged meals, will no longer be flea market items but take their place beside "produce" in "grocery" stores.

The demand will be augmented by the growth in the number of small outposts of humanity - on the Moon, in space, in space ships, among the asteroids etc. Small incipient outposts would be stuck in the "salad bar" mode indefinitely if it were not for trade with larger more agriculturally diversified settlements on the Moon, out in L5, or elsewhere.

Agriculture will slowly emerge as a major sector of the industrializing lunar economy. To turn an old phrase on its head, pioneers can not eat, nor clothe themselves, by metal, glass, and ceramic alone!

Cotton Plant Byproducts

In a response to a question about the possibility of growing cotton to meet clothing needs, Dr. Tibbits gave the sort of horse-blindered response typical of a specialist unaware of the universe at large. “That would mean withdrawals from the lunar biosphere, making it inefficient. We can’t do that!”

To the contrary, if a non-luxury settlement need can be met with an agricultural product that is 50% lunar oxygen by weight, and the only remaining viable option is to import something with 0% lunar content, then net efficiency of the farming unit be damned. It is the gross efficiency of the Settlement with all its systems that is the bottom line.

The “synthesis position” here is that any and all farm products withdrawn from the settlement’s biosphere must be processed, treated, and fabricated solely in ways that allow the item, material, or preparation to be eventually recycled and/or returned to the biosphere by composting. This holds of fibers, fabrics, and dyestuffs as well as of cosmetics and household preparations. We need to keep our eyes on this larger picture.

From the point of view of the plant species chosen for cultivation, in the interests of efficiency we ought to be looking for suitable ways to use the parts of the plant not normally eaten, as well as ways to derive food and other products from the composting remnant waste biomass. “Waste not, want not” must be the watchword of Lunar Agri-Business.

It seems quaintly out of touch, however, given all the ongoing progress in plant breeding, genetic manipulation, and biomass treatment, to reject a suggested crop on the grounds that too large a portion of the individual plant does not serve the primary purpose for growing it. What is to prevent the recombinant DNA researcher from putting into future cotton plants genetic instructions that make the rest of the plant a) edible; b) a source of pharmaceutical or other desireable compounds? The cotton plant - its not just for Haines anymore!

Recombinant DNA opportunities aide, three more conservative measures suggest themselves. First it is possible to develop varieties to maximize yield and minimize “waste”. Second, we ought to be looking at the waste of the unaltered plant as potential feed stock for useful by-products.

Third, biomass waste for which no useful purpose has been found does not have to go on the compost heap to produce “nothing but methane and mushrooms”, useful as both may be. In Wisconsin, Biotronics Technologies (W226 N555B Eastmound Dr., Waukesha WI 53186) has developed - for NASA - “biodigesters” which turn “waste” biomass into an edible tofu-like product that can be used as a food supplement or staple. These devices are demonstrating an efficiency of 98% — that is, there is a stubborn inedible residue amounting to no more than 2% the original biomass weight. We can dismiss the dismissers of cotton, then. Yet more research is needed.

The primary reason for raising cotton in space frontier farms remains fiber for clothing, bedding, toweling, cushions etc. Cotton is still the most comfortable fabric known to man, and happily the one with the largest oxygen content, making it the least expensive of all fabric options for any settlement or outpost dependent mainly on lunar resources. (Those who wish to try Jockey shorts made of fiberglass are welcome to do so.)

However, we currently subject cotton to a lot of treatments that would be inappropriate in a closed lunar biosphere. Mercerizing, which treats cotton yarns or fabrics under tension with caustic alkali in order to increase strength, luster, and affinity for dyes is an “unkosher” no-no — mixing organic and inorganic materials renders the latter unfit for recycling (i.e. the precious hydrogen and carbon content). Use of inorganic dyestuffs is out for the same reason.

Happily, breeding of new cotton varieties in which the fiber is “naturally colored” has already reached the market. Yellow-tan, rich brown, and green naturally-colored clothing, sheets, and knits bearing the Foxfiber brand are now available, with blues, yellows, and lavenders under development. This obviates the dying process altogether, along with the stress even vegetable dyes put on tightly recycling water systems.

All this means that the Cotton Goods Industry on the space frontier will look quite different from the one we are used to, even considering only the traditional fiber products. That industry will meet several important settler needs. Further it should provide a source of export income marketed to all pockets of humanity from low Earth orbit on up. For once the start up costs are amortized, Made-on-Moon cotton goods should be cheaper to deliver anywhere in space than those manufactured on Earth’s nearby but gravid surface.

But if cotton can be used to produce not only fiber and oil (cottonseed) but now also food (tofu) and maybe other products, it will join the prestigious company of other already well established “cornu-

copia" crops. As it happens, many of these versatile plants are also well known in the southern United States. We discuss some of them below. MMM

 **Sweet Potato Byproducts:**

 **Peanut Plant Byproducts:**

 **Soybean Products:**

The George Washington Carver Story

George Washington Carver 1864-1943, pioneer black botanist and chemist working at Alabama's Tuskegee Institute, motivated by a desire to improve the economic conditions of southern farmers, gardeners, and orchard growers, and driven by the conviction that "every waste product is an undeveloped natural resource", developed and patented over 300 useful byproducts of the sweet potato, and a hundred-some byproducts of the peanut. He also worked with the soy bean, velvet bean, and pecan. His research career spans the period '97-'37; his most creative work taking place in the 1910s and 20s.

Food byproducts included flours and meals, six breakfast foods, candies, donuts and breads, flavorings for ice-cream, a milk and derived ice cream and buttermilk, a worcestershire-type sauce, a soy-like sauce, a coffee-like drink "superior to Postum™", curd cheeses similar to Neufchatel and Edam, soft cheeses, a peanut milk from peanut flakes and water, a relish, punches and fruit juices, vegetarian steaks and meats, and more!

Other products included such diverse preparations as inks and facial pomade creams and perfumes, soaps and glues. He even patented a fabric, Ardil™, about which I was able to learn nothing at all.

Whatever food processing system he was using at the time yielded a residue, of course, and he looked at that residue (similar to mining tailings etc.) as a challenge and opportunity, as something pregnant with new possibilities. He experimented endlessly and prolifically with an open mind.

How many of his inventive concoctions and preparations are being marketed today? I don't know. Assuredly many of them must have been of inferior quality, from a consumer point of view, to alternatives on the market from other sources.

For us the question is a rather different one. On the early space frontier - a brave new world laden with "rough edges" - when importing ready-to-use food luxuries, cosmetics and household preparations will be pricey if not prohibitive, could some of Carver's patents be used to create a home-grown supply of some of these items on the Moon and in Space Settlements?

The answers will expectedly be a mixed bag. Without a detailed item by item patent search, it is impossible to say which of Carver's innovations require major secondary ingredients that will have to be imported. Some lines will offer more promise than others, to be sure. But for those interested in honing the edges of the rough early frontier, and making it a more attractive opportunity for settlement, a good deal of scholarly research awaits.

First (and none of this was I able to do at the central Milwaukee Public Library),

- √ get a definitive list of all of Carver's patents, if possible with the dates and patent numbers (but at least the dates); second
- √ look up each patent in question to uncover which processes and secondary ingredients he used in each case.

Some possible RESEARCH SOURCES for you to start with: national, state, and regional Peanut Growers' Associations, Sweet Potato Growers' Associations, etc. The Tuskegee Institute.

Even apart from a detailed look at Carver's work, it should be apparent to anyone observant that crops like the **Peanut** yield diversified products: raw, salted, and roasted peanuts; peanut butters and candies, cookies, and frostings (even milk shake flavorings, and I've stumbled on a soup recipe with a surprisingly complex and pleasing taste!) derived from it. The crushed peanut "cake" (minus the oil which itself is the start of a whole other family of products, some of them industrial) yields flours and meals.

Cellulose-rich peanut shells (36% of the pod weight is here) are a source of fiber - they even come in different hues depending upon soil chemistry. The fiber is not as hard as wood, nor as soft as paper. Peanut shells are also easily turned into a suitable craft material for children's temporary crea-

tions, easily recycled later provided any decor materials used with it are kosher (organic and themselves biodegradable like vegetable dyes). They can be cut, shaped, filed and filled, painted, glazed, glued, and strung. Their use on the space frontier for this purpose would help stimulate young creative and artistic imaginations, used in whole or part to make toy people, animals, abstract designs, and jewelry. Even peanut shell sawdust with an organic binder makes a workable child's clay.

The top of the peanut plant is used as fodder along with the press cake of peanut seeds. Does not such a crop, with its promise for food sector industrial diversification, merit serious consideration for a major place on space frontier farms?

The Sweet Potato, Soy Bean, Peanut and other multi-use crops are also key to enriching and diversifying not only space frontier menus, but the whole existence of the pioneers. Those planning lunar and space agriculture have to take off the horse blinders and start looking beyond the salad bar - way beyond! Rather it is the single use crops that should be afterthoughts. This amounts to a revolution in current thinking.

We cannot wait until CATS, Cheap Access To Space, suddenly opens the gates to the frontier to start thinking about these things. The time to roll up the sleeves and put on the thinking cap is now.

MMM

Saproculture & Saprochemicals

Fungi, Mushrooms, and some Orchids are among the better-known plants which grow on decaying vegetable matter. Many of these plants are poisonous. In addition to the well known variety known as the mushroom, agaricus campestris, there are many other species of mushrooms which are not only edible but almost addictively delicious and delicate. There seems to be a widespread myth, moreover, that such plants offer empty taste without real nutritional value. Not so!

Where there is agriculture, there will be waste biomass with which to make compost or feed the biodigesters. Why then limit food production to the anabolic photosynthetic part of the biocycle? If food, especially something to add diversity and interest to limited frontier table fare, can be teased out of the biomass decomposition cycle, that makes the whole farming process that much more efficient.

While there is, to be sure, a minority with insensitive taste buds who do not appreciate fungial foods, for the sake of the rest of us there ought to be concerted research on home growing of other mushroom and truffle varieties now mainly picked in the wild. Next you can experiment with ways of serving and preparing your harvest: stewing, sautéing, frying, grilling, stuffing, etc. (The Encyclopedia Brittanica under "Mushrooms, Cookery of" even gives a recipe for "mushroom ketchup"!) Here is yet another space research project for you home gardener types. Our spiritual descendants sitting down around space frontier dining tables will remember you when they say grace.

But let's go one mighty big step further. Wouldn't it be utterly amazing if the various catabolic processes at work in the compost heap or the biodigester did not produce liquors and exudates that could serve as alternative feedstocks for a frontier chemical industry. Here is a whole new field of research for you organic chemists out there. Why not take a stab!

Bioextraction of Trace Elements

In MMM # 63 MAR '93 Lunar Industrialization, Part I, "BENEFICIATION", p4 we tried to stress that the elements present in the "oreless" lunar regolith in major abundances can not adequately underpin an autonomous industrial base, that we need to learn to efficiently extract other elements present in parts per thousand, parts per million, even parts per thousand concentration. This is a tall order for tried and true chemical engineering methods, especially for the lesser trace elements present. There is another tack: Bioextraction.

We can start with soils known to be atypically enriched with the desired elements. Fra Mauro basalts (Apollo 14 Antares mission) are richer in Br, Cl, F, Pb, Zn. KREEP soils splashed out from the Mare Imbrium impact have Cl, Pb, Br, Zn, and Ag on grain surfaces, in higher than expected ppm and ppb concentrations. These are all water-leachable.

Leach water from such soils can then be used to host element-concentrating bacterial and other cultures. Harvested bacterial, microbial, or yeast material would then provide us with an organic "ore", a higher plateau from which to then apply standard chemical engineering methods.

Bioextraction can be piggybacked on the importation of soils into pressurized farming areas, or practiced separately. Either way, it is critical to lunar industrialization. MMM

Arborculture, an alternate path?

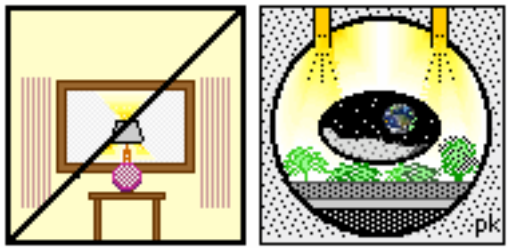
A couple of years ago I read a short illustrated piece on something dubbed "arborculture", probably in Popular Science or Popular Mechanics, but I haven't turned up the actual source. In this proposed alternative to "agriculture-as-we-know it", the sole conventional crop grown would be a species of fast growth soft pulp tree.

The harvested pulp would then be finely powdered and, with water added, become a nutritious broth for a wide variety of specially engineered bacteria which would thereupon busily and efficiently produce all the end-use food and fiber tissues and other organic products we desired with near zero biomass waste for extremely high food growing efficiency.

The proposal was not specifically put forward with the space frontier in mind, but the potential suitability should be obvious. Something to keep on the lookout for. MMM

Read more at
http://www.brainyquote.com/quotes/authors/g/george_washington_carver.html#mQgSz7toBCvuYeIS.99

MMM #76 - June 1994



Windows - out with one cliché, and in with another

Driving along at night one sees home after home with a lamp on a table in front of the picture window? Poor decorating actually, but commonplace. On the Moon, with very little pedestrian or motor traffic "outside", exterior "presentation" will rate low.

Ranking higher will be the need to gaze on the stark moonscape through the reassuring foreground of living foliage and flowers, under solar spotlights. More on lunar homestead interiors, below.

[Editor: the author of the series of pieces that follows has his own one man "This Old House" business and specializes in custom home interior remodeling and redecoration. His hands-on experience working with all sorts of building and construction materials and in getting the most out of them under oftentimes difficult conditions has filled him with enthusiasm for this "ultimate challenge" to home-crafting resourcefulness.]

INSIDE MOON MANOR
By Peter Kokh

In the previous issue we speculated a bit about the possibilities for a modular lunar-appropriate homestead architecture reliant on locally produced building materials. Until such a far off day arrives when new homes are built within atmosphere-retaining megastructure units, traditional box-type homes are ruled out. The need to contain atmosphere against a vacuum under a protective shielding overburden will result in homes with curvaceous exterior shells or "hulls": curved side walls and ceilings and cylinder end caps. Such shapes can be put together to yield a great variety of floor plans and lay-outs.

We learned that the alcove-like spaces of hemispheric cylinder end caps will be an opportunity for "snug-in" furniture with a built-in look. We saw too that these caps are the logical modular element by which both visual and personal access is provided, in alternative versions.

In this issue, we take a further peep inside the Lunan homestead. We'll look at the building materials likely to be available in the early settlement and their implications for interior decorating options. While Lunans will have less choices, with resourcefulness, a great deal of decorative variety should be possible, nonetheless.

MANUFACTURING AND ASSEMBLY OF INTERIORS

By Peter Kokh

So far, our speculative Lunan Homestead is just a shell, one continuous labyrinthian space. In a pinch, that'll do. Heck, we can string up a blanket or sheet to provide privacy where needed, but that is certainly no long term answer to the need for structured, subdivided space to house a variety of rather different activities. We will want interior partitions or walls and interior doors and doorways. These can, and will be added afterwards - after construction and pressurization and utility hookup, and after the new occupants take possession. For as we have seen, the need to provide safe basic shelter in as timely a fashion as possible will be paramount. All other "secondary" shelter needs will have a much lower priority, that is, no real urgency at all.

All the same, how will we provide partitioning? We won't be able to order a load of 2x4s and dry wall sheets. Even if the settlement farm can produce wood as a byproduct, the young biosphere can ill afford to see its carbon and hydrogen content withdrawn from quick turnaround circulation to be "banked" instead in so comparatively frivolous a pursuit.

If indeed economically recoverable lunar polar water-ice deposits are found, then gypsum, the hydrated calcium sulfate used in dry wall could be produced. To produce dry wall or sheet rock itself, we'd also need a substitute for the paper/cardboard surfaces used to sandwich the gypsum in sheets. Some sort of tight-weave fiberglass might do. This lunar dry wall could then be used with steel 2x4s now widely used in fireproof construction.

Baring this fortunate orbital prospecting find, and subsequent ground truth confirmation, the more likely building materials for walls are steel and aluminum panels, with steel easier to produce for the early settlement, and glass-glass composite (Glax™) panels, the same likely stuffs used in fabricating the homestead's modular shells themselves, making for consistency in decor treatment . Brick, sinter block, and glass block are likely to have limited application where the permanent decorative look and feel they provide meet the original homesteaders' needs and desires.

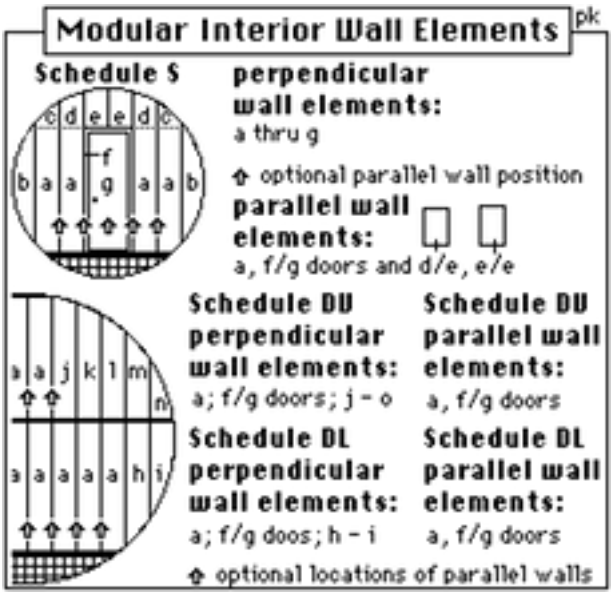
Will available building materials be brought into the homestead from the warehouse with fabrication to take place on location with all the attendant dust, debris, and cut off waste? This may be the custom on Earth where the specifications of the particular job vary enormously. But for Lunan homesteads built of lunar-appropriate modular construction elements, the wall-spec variations will form a very limited set. Walls will either fit spherical cross-sections of cylinder modules or center or near-center rectangular sections along the length of the cylinder. In either case, they can be manufactured with in-factory efficiency for onsite snap-fit erection by again designing a very limited number of modular elements.

We suggest wall sections of a varying ceiling contour and height but with a standard 50 cm (19.77") width. A double clear space would provide a "rough opening" for a door 1 meter wide (i.e. 30.54", and why not 2 meters i.e. 79.08" high). If each module has a pair of retractable pegs or dowels on both bottom and top to fit matching holes pre-drilled into floor and ceiling on a 50 cm (half meter) grid, the modules could be put together to make a wall easily, and taken apart and reassembled elsewhere when desired.

The modular wall elements could be hollow or honey-combed, with or without inner acoustic insulation. Each of the various elements could be equipped with surface screw actuated KD ["knock-down"] connectors for easy mating. Surface screws would also actuate panel to floor and panel to ceiling pegs or dowels.

The various wall panel elements might also each be fitted with male-female electrical interconnects feeding one continuous service strip on each side of the wall panel.

If our suggestion for modular architecture were to be adopted, 3 principal "schedules" of wall module elements would do the trick: S(single floor module); DU(duplex cylinder upper floor); and DL (duplex cylinder lower floor). MMM



SURFACES AND TRIMWORK

An Exercise in Resourcefulness — and Creativity

By Peter Kokh

Unavailable on the volatiles-impoverished Moon are:

Woodwork trim moldings

Wood and wood byproduct **paneling**

Plastics and hydrocarbon-based Synthetics

Wallpapers and wall coverings of all sorts

Oil (Alkyd) based **paints**, stains, varnishes

Latex (Acrylic) based **paints**, stains, varnishes

Still available for the resourceful homesteader are:

Steel, and **Aluminum**

Brick and **cinder block**

Ceramic tile - however, no lead-based deep colors and no lead-based high gloss glazes

Glass & Fiberglass-glass composites: Glax™ **Pyrite** (FeS2) brass-colored surface coating of steel

Waterglass/oxide based* paints, stains, varnishes and "texture paints" with regolith pastes

Titanium or lime (calcium) "whitewashes"

[* NOTE: No known experiments to date but LRS-sponsored R&D to begin shortly, and to include application tools.]

And IF water ice is found in quantity at the poles:

Concrete ("lunacrete", fiberglass reinforced, fiberglass surfaced cement board (Duroc™)

Plaster or **drywall** (hydrated calcium Sulfate)

The "ultimate resource" of any Settlement is the talent pool & creative resourcefulness of its people — not mere natural endowments.

Background Readings in MMM's Past [Republished in MMM Classics #7]

MMM # 63 March '93 pp. 4-11: Beneficiation; Sintered Iron; Alloys; Glax; Glass; Ceramics; Color the Moon.

MMM # 65 May '93 pp. 5-6. Sulfur; Moonwood

[NOTE: **A word about Prerequisites:** the discussion that follows assumes that the necessary homework has been done in learning how to isolate, under realistic lunar conditions, all the "workhorse elements" needed to make a useful stable of alloys, glass formulations, and colorants. See MMM # 63 reference above. Very little of this homework backlog has been done by NASA, by industry, or by capable individuals. It is MMM's belief that much of the know-how needed on the lunar/ asteroidal/space settlement frontier can be pioneered for profit here and now, solely for the terrestrial applications. All that is lacking are motivated and talented entrepreneurs.]

Design Preferences: Simple Minimalism vs. Ornate Maximalism

There has to be a balance in life. In Victorian times a century ago, when life and living were far simpler (or do we simply forget the problems of times gone by) home interiors were customarily ornate, excessively so by today's standards. The wood furniture was highly carved, of complicated design, and often with marquetry inlay and other embellishment. Wallpapers and fabrics were "busy". Things made of iron were full of curves and flourishes.

The Art Nouveau period that followed freed the curves from symmetry, replacing that sacred cow with free spirited "balance", yet keeping all the curves in homage to nature. Art Deco came along and substituted the rectangle, triangle, and diamond - straight lines and hard angles in general, but keeping the new free spirit.

Then we languished in a state of eclectic poor taste for lack of inspiration. From this we were rescued by the simple straightforward "form is function" and "simplicity is elegance" of modern design. Many enduring different fountains of creativity here: Frank Lloyd Wright, the Bauhaus, Danish-Scandinavian design - to take a broad potshot at the spectrum.

Modernism installed a slavery of its own. Happily these days, we are each free to express ourselves as fits our own soul's needs: with simple, graceful, minimalist elegance - or with wild, life-embracing detail - or anywhere in between.

When it comes to our picture of the future - and of space - the image of steel and plastic and plain lines has taken on a life of its own with no basis or justification at all in reality. In many frontier situations, plastics and synthetics will be prohibitively expensive exotic import materials. More to the point, the barren desolation of most, if not all, settlement settings in contrast to the lush host biosphere we all enjoy on Earth (even in the desert, even in the tundra) will stuff the pioneers with as much simplicity as they can bear, perhaps more. The deep psychological need will be for homes that are oases of rich detail and interest in this design desert.

Many of the suggestions for decoration illustrated below will strike the reader as being out of touch with today's spirit. We protest that today's spirit bears no relevance to the needs of the frontier. Frontier lives will be difficult, but hardly as over-structured and complicated as is common in our own contemporary situations. The one thing that will hold true for them as for us is that overriding cosmic need for balance.

Variety in a small market

What is needed is not only a number of different ways to decorate with interest, using few basic materials, but also ways in which to customize the effect. For manufactured items, computer assisted manufacturing or CAM offers promise. It has traditionally taken hours to effect setup changes in machinery to alter the product design or finish, and only premium cost or large demand justified the loss of productivity such change-overs required. Nowadays, smart machines can customize each item without missing a stroke. A small market and small total product run need not mean that only one kind of anything is made, that everyone's wares and wears are indistinguishable.

At the same time, such "kaleidoscope machines" have limits. And the role of art- and craft-finished items will be important. Scarcely in history have artists and craftsmen enjoyed as much prestige as they will on the frontier. Never has the personal touch been as valued as it will be. To serve this need, some quantity of every item might be made "ready-to finish". The trick is to design items that can be finished in an open variety of ways, either by the professional, or by the do-it-yourselfer working to his/her own satisfaction.

This will apply especially to furniture and furnishings. But we jump the gun and bring up the subject here because it applies to surface finishing in general. And living spaces as defined by floor, walls, and ceiling are an important instance.

The surfaces in question will include metal (steel, later also aluminum), glass, glass composite, ceramic, and cast basalt, and sintered regolith block — plus lunacrete or plaster or lunar dry wall only if water ice is found to be abundant.

Surface treatments: metal can be embossed, engraved, and oxidized (rusted) or pyrited (sulfur treated for the brassy yellow look of fool's gold); it can be polished or sanded for a shine or satin sheen. It can be chrome-plated, or stainless.

Glass and glass composite can be stained and etched and mirrored. Cast basalt can perhaps be given the mold-transfered look of crosscut sawed wood, of bark, leaves, or other "nature collages". Sintered regolith brick can perhaps be produced in pleasingly variegated grays with homogeneously colored regolith in waterglass serving as mortar. Tile can take on the color of oxides, left unglazed or given a salt (sodium) glaze. Vitreous glazes without a lead-based flux are possible in many colors and hues, even if neither bright nor deep.

Surfaces with sufficient "tooth" or fine-scale roughness can perhaps be whitewashed with titanium oxide or calcium oxide (lime) powder suspended in a waterglass medium. Perhaps colored oxide pigment powders in the same medium can be used as paints. We see that there is plenty of room for experiment and the promise of amazing variety.

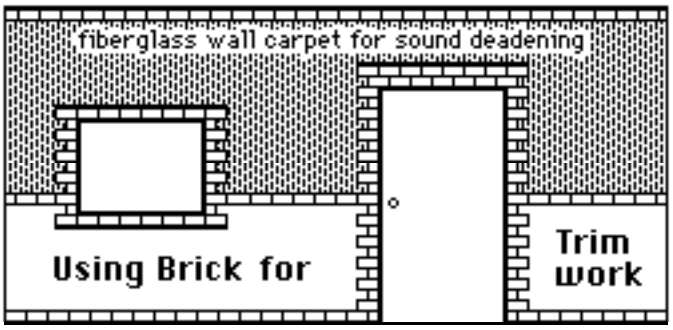
Special wall and trim treatments

Woodwork, to which we are so accustomed in our homes the world over, is not a lunar-appropriate choice. While good "furniture quality" woods could be produced by apple and cherry orchard trees, the settlers will not be able to afford to withdraw and bank that much incorporated hydrogen and carbon from the biosphere-food production cycle.

One option is the "trimless look", a natural for manufactured walls and wall module systems. For example, door and window frames are seamless features of the adjoining wall (modules) and not set off in color, texture, or any other visible way as "border" areas. I've seen such a look in Mexico City's D'el Angel Hotel, and it is strikingly refreshing.

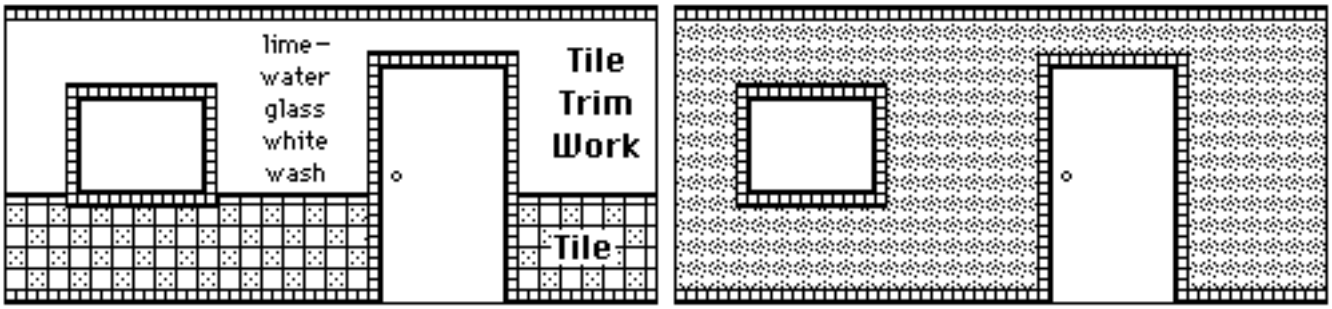
But where desired by the homesteader, the edging and border setoff function of woodwork, can be simulated by lunar-producible inorganic materials such as thin veneer (Z-)brick, ceramic tile, and metal "**trimwork**".

These choices are illustrated below along with several possible companion wall surface treatments. As a general rule of good taste, when the chosen trim is ornate in feel, wall surface treatments should be simple; and vice versa.



In the illustration above, the soft look of “carpet” is chosen to balance the rough look of the brick veneer. However, as organics and synthetics are not available for this purpose, and fiberglass carpet would wear poorly, being too brittle to take repeated crushing of the fibers, the latter is applied to the upper walls, out of harm’s way, so to speak, but still contributing to the sound control and providing visual softening.

In the illustration below, ceramic tiles are used to provide trim borders. While the seemingly endless variety in color, pattern, and glazing now available on Earth could not easily be produced on the Moon, a variety of hues from the lunar palette (regolith grays, oxide colors, stained glass colors) should be available either unglazed or in soft satin glazes. Tile in contrasting sizes, and coordinated colors and patterns, would make a good companion wall finish, as would simple white-wash or waterglass-based paint.

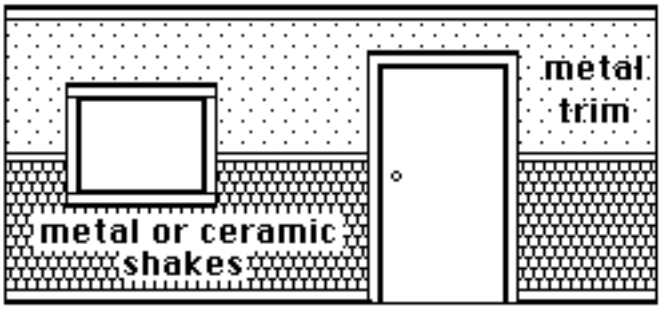


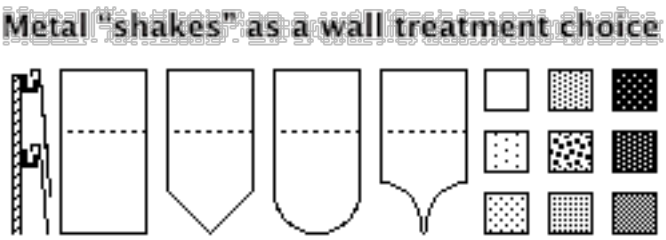
Simulating the “wallpaper look” with lunar paints

In this schema, the walls are first primed with a “whitewash” of lime in a waterglass solution. When this is dry, any of a wide variety of wallpaper like patterns can be sponge-painted over the base white, using metal oxides, again in a waterglass medium. Imported natural sponges of various textures and shapes can be used over and over again as the “paint” is water soluble. The technique is much faster than wallpapering and the results can be “painted over” when a change in color and/or pattern is desired.

Projecting a transparency of a scene or panorama to be transformed into a mural, one could follow the pattern with variously textured sponges dipped in various waterglass-metal oxide “paints” to create a result with an “impressionist” feel.

Other possibilities with waterglass-based coatings are in need of investigating. How about applying a clearcoat of waterglass and while it is still wet, random- or pattern-flocking with dry oxide powders or regolith powder? This could be done on site with by blowing through a hopper-fed (self-choking feed) straw equipped with variously shaped nozzles to alter the dispersion pattern (as in decorative cake-icing devices). Under factory conditions, flocked panels could be produced to order by computer controlled blower-printer. What would the effect be like? Has anyone yet tried anything of the sort? I suspect not.

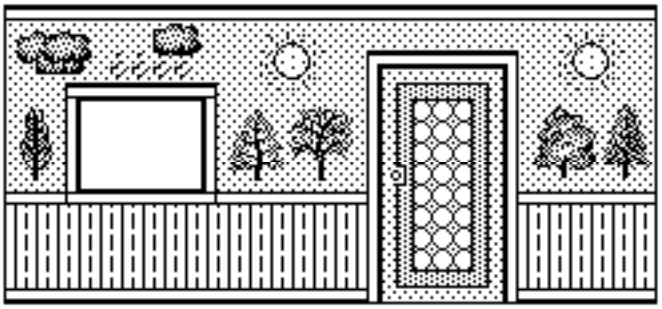




Using a repertoire of four differently edged shingles, each available in any of a repertoire of waterglass-oxide colors, a large-pixel mosaic tableau can be created. Working up from the floor, the metal shingles could snap into horizontal channels prepositioned on the wall, with a special topper strip. A computer could analyze a picture, pixelize the pattern and color codes, and list the elements to be purchased.

Geometric and Pictorial Panels of Embossed or Beaten Aluminum "Sculpsheet".

If Lunan metallurgists can formulate an alloy of steel or aluminum malleable enough to permit the kind of sheet working that has long been practiced in copper, brass, and tin, bas relief patterns or tableaus could be either mass produced in a number of popular styles, or handcrafted on commission. The patterns or scenes might be "highlighted" by careful use of waterglass-oxide "varnish-stains". This form of wall treatment might be an attractive choice for dens, libraries, formal dining rooms, entry ways, even for "front door" facings.



Less ornate and ambitious would be steel "paneling" of interlocking or tongue in groove narrow strips. These could all be finished alike or vary in a set sequence. Finishes that might be used include stainless with smooth, embossed, or satin-finish, chrome, and Pyrite surfaced steel. The latter, being of false gold, iron sulfide FeS2, would have a brassy-yellow finish. (Brass and copper are not lunar-available).

Artist-Craftsman, Tradesman, & Do-It-Yourselfer

The settlement market should work to ensure the entrepreneurial supply of a number of satisfactory alternatives for three overlapping degrees of expertise, talent, and available effort. Within each there should be choices to fit various budgets. The result will be a surprising and spicy variety between individual personalized lunar homesteads.

Special Wall Surfaces

Tub surrounds, shower walls and sink back-splashes can be glax one piece units, of standard size and shape and fitting interfaces, available in a variety of colors and patterns and textures, thanks to the ease of setup changes possible with computer-aided manufacturing methods. MMM

ON THE WALL

Problems & Solutions for Hanging Stuff

By Peter Kokh

On Earth, it is no problem to hang something on the wall: pictures and paintings, macramé hangings, copper and wire sculpture, plastic bric-a-brac, mirrors, wall lamps and candle sconces, knickknack shelves, shelving systems, clocks, or whatever else is not too heavy and not too deep as opposed to high or wide. The reason it is not a problem is that the sundry wall stuffs we build with such as plaster, dry wall, and/or wood are all medium density materials. They are soft enough to pierce with a nail or screw, and firm enough to hold such fasteners. Even concrete, brick, and cinder block - all denser and harder - have fastener systems designed for them that are more difficult, but not impossible to use.

On the Moon, the most probable wall materials are steel, aluminum, and glass-glass composite or Glax™. These are very dense materials, and while it is possible to drill holes into them, "repairing" the "damage" when one wants to redo a room and hang the same or other items elsewhere, exposing old wall-wounds in the process, is something else.

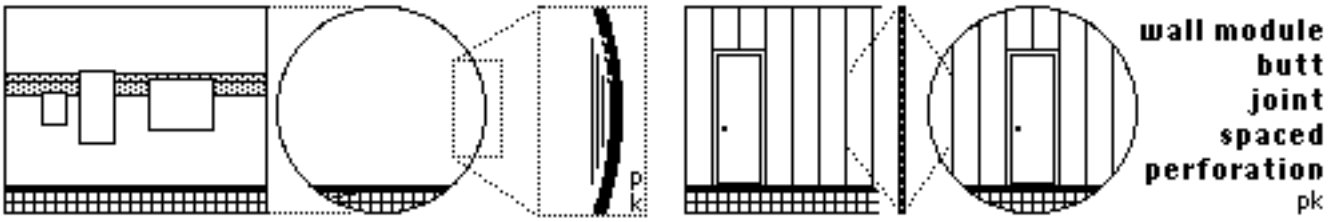
Cable-wrapped fiberglass reinforced lunar concrete is a remote possibility as a hull material. Some sort of cinder block is a conceivable but unlikely material for interior walls. For either of these, however, a waterglass-regolith mortar should be available in a wide range of gray shades. But as these wall materials are the less likely, let's concentrate on the problems posed by metal and glax.

If repairing "nail holes" is the problem, the simple answer is not to make any in the first place. Yet our Lunan homesteaders will want to personalize their quarters not only by room surface decoration (paint, paper, panel, trim) but by hanging artcraft items and other objects "on" the wall. So we are faced with a design problem: how to design walls so that hanging things on them requires no added hardware, no added holes, etc.? We could limit ourselves to steel walls requiring only magnets. But let's brainstorm a bit more thoroughly.

Our settlers will face two situations: (a) curved outer hull walls (either cylindrical or hemispheric concave surfaces); and (b) flat interior walls. Most likely the kind or at least the size and placement of things we will put on curved surfaces will show more restraint than the total freedom we are accustomed to enjoying with traditional flat walls.

On the horizontally concave outer walls of cylinder modules, only the central portion is suitable for holding things flat so that both top and bottom of the object 'touch' the wall.

For this purpose, a series of built in hanging strip grooves is a solution that may work, and even presents decorative possibilities, i.e. as a broad horizontal stripe. Objects can be then hung anywhere along the length of the wall, utilizing the hanging groove that best suits their individual height. While the result may be that pictures and other objects are hung slightly below the customary "eye-level", the hanging grove stripe, perhaps differentiated by texture and/or color from the rest of the wall, will be at the top of this range, serving as a visual corrective of sorts.

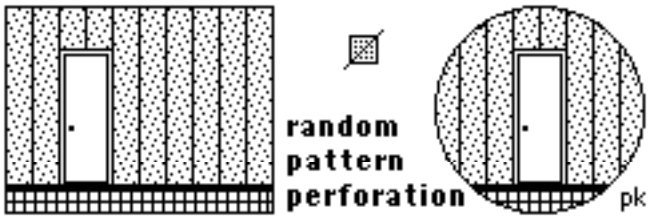


This hanging system can be repeated on flat interior walls, especially if one wants to continue the visual effect of the color/texture differentiated hanging stripe. If not, i.e. if one wants more freedom

for flat interior walls, then the hanging “stripe” should be visually minimized by not distinguishing the space between the hanging grooves by texture and/or color.

Bearing in mind the suggestion that interior walls be modular, with sections 50 cm or 20” wide, then the butted edges can be “perforated” to allow hanging objects at any height along them.

The constraint of having to space sundry hangings on 20 inch centers may be acceptable to some, not to others. An elegant alternative might be random perforation of the wall panels themselves. The result would not look like “pegboard” for two simple reasons: first, the hole spacing would not be in noticeably vertical and horizontal “rows”; second, the holes would be much smaller, say just large enough to admit a 6d (6 penny) nail, slanted downwards to a depth of say 1 cm or 1/2 inch. The effect, both visually and acoustically would not be unlike that of some acoustic ceiling tiles.



There is, of course, ample precedent for “nail hole control”. Many rental and lease agreements stipulate that the tenant or lessee must either repair any holes made, or use adhesive hanging methods - neither a practical option for our settler, given the wall materials likely to be in use. However, much earlier in the present century, it was common to place a “picture hanging molding” just below the ceiling. Anything hung “on” the walls could then be suspended by decorative cords, clips, and tassels from such a molding. That is a look long out of favor and not likely to find fresh converts. But it embodies the philosophy of built in “purchase points” for hanging various items “on” walls that we’ve tried to borrow.

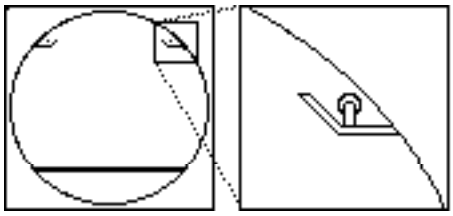
Again, what we have tried to do is to illustrate the distinctive look of Lunan homesteads that is likely to flow from the constraints inherent in the building materials settlers are likely to have as options. With resourcefulness, such restrictions will trickle through to homes no less custom personalized, nor less beautiful than those left behind on Earth. While options will be less, the possibilities are varied enough that no one will be able to say, “when you’ve seen one Lunan homestead, you will have seen them all.” And in a world many magnitudes of order “smaller” in population, the pursuit of distinctive variety for its own sake will be intensely pursued.

A large part of our sense of world, is not just size, but wealth of diversity and variety - in scenery and terrain, in . plant and animal life, in climate, and in architectural and interior decoration styles. With first just one, then a few more settlements and outposts on the Moon, the settlers will turn to variety in home decoration, not only as the spice of life, but as the principal way of validating their new adoptive satellite as a human world - one with depth.

CEILINGS

By Peter Kokh

How do you define “ceiling” in a habitat space in which the walls curve up overhead and over into one another without any break in the flow? If there is a cove well above eye-level to support ambient cove lighting, the area between the coves might be pragmatically defined as ceiling.



Continuous Cove Light Strip with Reflective Lumination off Ceiling

In some decorating schemes, dark ceilings have been used especially to visually "lower" them when the actual height is too high for one's taste. Ceilings have also borne lavish decoration. The Sistine Chapel in the Vatican is the most famous example (the one in the Governor's Conference Room in the State Capitol in Madison comes close enough). But recall also the molded tinplate panels that were commonplace in commercial halls at the turn of the Century (19th to 20th).

But overwhelmingly, ceilings have served as indoor surrogates for the sky, surfaces meant to reflect ambient light brightly. Accordingly they are traditionally painted in flat or other soft white are light pastel shades. On the Moon, we'll probably see examples of both. The ornate design showpiece may be a high end budget choice as a focus of attention for meeting places, banquet halls, and just plain dining rooms.

But overwhelmingly here on the Moon where the outvac sky is black, the Earth-reminiscent overhead brightness of the sky will be repeated in homestead ceilings as repositories of soft rich unfocused reflected light. For this purpose a waterglass Ti2O (titania) and/or CaO (lime) whitewash should work. If a blue oxide pigment can be produce, we predict sky blue will quickly replace white as hue of choice. MMM

FLOORING

By Peter Kokh

In the context of the modular Lunan homestead, three subtopics of interest suggest themselves when it comes to floors and flooring. These are structure - how they are built and installed, function - what purpose these structures might serve besides providing surfaces to walk on and set furniture upon, and finish - what they might look like and feel like underfoot.

Structure: In sixthweight (1/6th G) truss members can be much less massive. We are talking about short 10-20 ft. (3-6 m) spans. Floors and truss/joists can be integral panelized elements, and in the case of two-story applications, incorporate ceiling surfaces as well. Since customer customizing does not seem to be in question, they might best be designed for more efficient factory-installation module by module prior to assembly of the separate homestead modules on site.

Function: if flooring is panelized or modular, ought it be removable? Removable decking could give access to storage space underneath as well as to utility runs (plumbing, ventilation, electrical, communications) connecting the various modules. Yet to the extent trouble free systems are involved, ready access looms as a less important requirement. Nor is subfloor storage especially convenient. More, it might interfere with some finishing options, e.g. installation of ceramic tile.

Fixed flooring could 1) serve most of the utility run needs 2) incorporate a radiant in-floor heating system, the most efficient and comfortable form of heating yet devised, 3) top off a thermal mass reservoir. The latter would be especially attractive if some lunar-sourceable form of eutectic salt can be discovered. [A eutectic salt is one that changes phase from liquid to solid and back at a convenient temperature in the mid ambient range with a relatively large heat input/output i.e. storage/release.] To my knowledge of lunar resources, that is an unlikely prospect, however welcome it would be.

Finish: On Earth, popular flooring choices include carpeting, wood plank or parquet, vinyl tile or sheet (linoleum), slate, and ceramic tile. On the Moon, only the latter is a real possibility, along with steel, glass composite or Glax™, and tiles, bricks, or slabs of cast basalt.

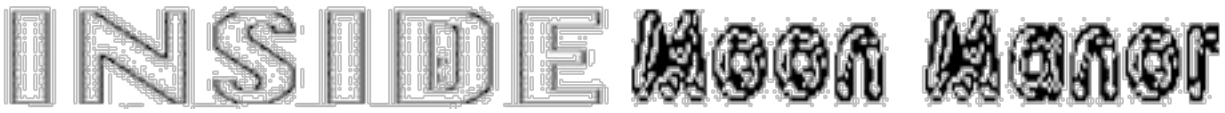
Carpet can be made of natural or synthetic organic fibers. In either case, for lunar application, it would tie up priceless hydrogen, carbon, and possibly nitrogen that is best used to maintain and grow the biosphere. What about carpets made of fiberglass fibers? After all, fiberglass draperies are a common choice. The problem is that for all their strength, glass fibers are brittle and stand up poorly to wear, and other abrasive abuse. For draperies that is not a problem. Underfoot it would never work. However, glass fiber carpets could still be applied to walls, out of harms way, there to contribute to acoustic control and visual softening.

Cast basalt pavers are the one possibility mentioned that deserves the most homework. Baring that, ceramic tile and textured steel, pyrited for color, will be the workhorses. MMM

If carpeting is out, perhaps throw rugs made of discarded clothing are not – especially clothing made on Earth, gaining passage as the allowable maximum of settler recruit clothing, and produced through "unkosher" processes that make recycling and/or biodigesting of the constituent fibers difficult or "not worth the effort". But is it not more likely that most recruits will head the request (if it is not indeed a requirement) to bring along only recyclable clothing? At any rate, in sixthweight, expensive resilient material is more efficiently invested shoe soles always in use, than in carpet that for the most part just lies there. MMM

MMM #77 – July 1994

[Editor: one of the stints on the author's resumé is that of former furniture salesman in the early 70s. His familiarity with furniture and home furnishings earlier and continued to broaden thereafter.]



INSIDE MOON MANOR

Part II: Furniture and Furnishings

By Peter Kokh

In the previous issue, we took a look at "the look" of Lunan homestead interiors, insofar as they will be constrained by the materials to which settlers may well be limited.

In this issue, we take a further peep inside the Lunan homestead. We'll look at the list of furniture-making materials likely to be available and how Lunan furniture designers might express themselves in such media. Then we'll take a non-exhaustive look at furnishings or accessories. These articles will complete this MMM series on first generation Settlement Quarters. Related pieces will appear occasionally. MMM

CINDERELLA STYLE

By Peter Kokh

It might seem that without wood and plastics, stuffs for furniture making available on the Lunar Frontier only at exorbitant cost, compensated by a corresponding reliance on such New Stone Age materials as metal alloys, ceramics, glass, and glass composites, that the "Style", if any, achievable by Lunan furniture designers, will not much surpass those of the Golden Age of Bedrock way back in Flintstonian times.

That would hardly be a fair assessment. Mature style is less limited by the kinds of media on hand than by the artist/ craftsman's knowledge of the innate potentials of the materials and access to,

and skill in using, appropriate tools. Even now, kindred materials are used on Earth to make sundry furniture items of premium quality, with a respectable market share.

But it is the absence of wood, organic and synthetic fiber, and plastics altogether as an option that will bring forth all the creative resourcefulness of the designer and craftsman in developing for the first time the full range of potential of the available materials. The results may be copied, or on the other hand anticipated, in the growing areas on Earth where wood is scarce, or more sorely needed for other purposes.

Combine this prospectus with the need to provide personal customized variety in what will for a long time be a very small market, and the challenge becomes stronger. One way to meet that challenge is to mass produce basic items in a simple functional design, "**issue**" (cf. G.I., government issue), that on the one hand has its own grace, and on the other lends itself to subsequent embellishment or elaboration, becoming a canvas, so to speak, for middlemen cottage industry artists and craftsmen, buying issue items wholesale and reselling them out of their homes or in streetside shops after they have been transformed under their skilled hands. Such items assuredly would be in great demand. Customers could buy "issue" items "factory-direct" for use as is, to give to a chosen artist for customizing on commission, or for do-it-yourself adornment.

Such an evolution of consumer product lines ought to merit real Frontier Government support. The brand new pioneer settlement culture, without access to the vast variety of manufactured goods available on Earth, will find in art/craft finishing of common ready to finish items an ideal way to provide the essential perk of custom individual variety. It is in the public interest to promote such development.

Once a "University of Luna" has been established, such art and craft activity aimed at making Lunan Homesteads more satisfying places in which to live, would appropriately become a major outreach concern aimed at full development of the widest possible range of Moon-appropriate art forms, materials, media, methods, and tools. Support for individual artists involved in this art/craft activity in collaboration with the University should extend only through the R&D phase. The market, expected to be quite vigorous, should be trusted to support mature expression in such newly developed Moon-appropriate forms.

What to make for furnishing the homestead from this burned out "cinder" of a moon? The "Cinderella Style" of the frontier will rise to the occasion. MMM

FURNITURE

for the Lunan Homestead

By Peter Kokh

Furniture is commonly divided into three broad categories: 1) "CASE GOODS" include items commonly made of wood: bedroom sets, dining room sets, living room tables, desks, bookcases, etageres etc. 2)"UPHOLSTERED GOODS" are just that: fabric-covered and cushioned chairs, love seats, and sofas. Modern bedding, mattresses and box springs, would fall into this category. 3) "ACCESSORIES" include lamps, pictures and other wall-hung items, table top sculptures, etc.

Metals have long been used for case goods, but their market niche has been narrow: office and patio furniture principally. Glass has been used principally for table tops. Ceramics principally for lamp bases.

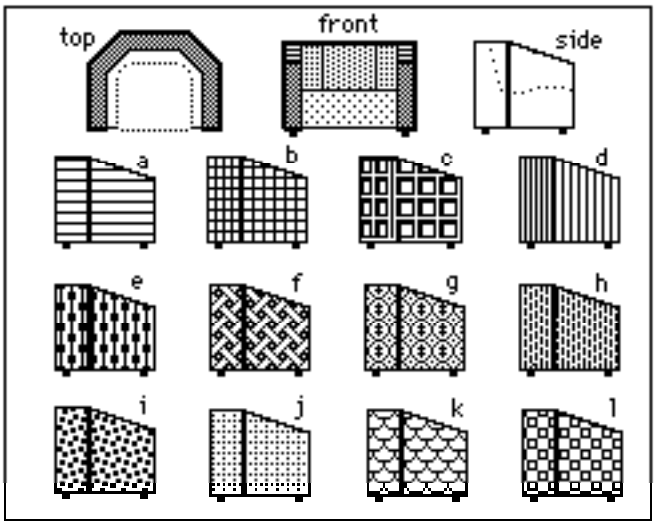
Glass composites, the sleeper, has not been developed at all as a furniture item (or for any other purpose) but has enormous potential in superior serviceability and performance, as well as in visual appeal (cf. our previously published suggestion in MMM #16 JUN '88 "Glass Glass Composites" [Republished in MMM Classics #2] that a formulation in which the glass fiber is colored or stained and then combed within a transparent glass matrix to provide a material with all the "grain character" of wood, be pioneered for the high end furniture market in order to pay the high initial development costs of this

new material. Glax, to use the suggested generic trade name, may lend itself to the same fabrication techniques as current fiberglass reinforced plastics. This means it should be suitable for molded contour fitting seating, as well as for structural framework, replacing wood.

Below we offer a number of product “studies”, trial balloon designs of “issue” items that can either stand as is or be further embellished, all according to customer taste. (Recall that in the last issue, we predicted a turn away from the elegant simplicity of modern and minimalist styles towards more design-intense items as a psychological counterweight to the monotonous barrenness of the lunar surface surroundings.)

Cathedral Choir Style Box Chair, Love Seat, Sofa

In the illustration below, a glass composite molded seat and back, the actual “contact surface”, is given an open supporting framework which can either stand alone or support encasing artcrafted panels of various types on the outfacing sides and back to provide a heavier, more design-intense piece. The variations shown do not correspond one for one with any specific possibilities, but are simply aimed at getting across the idea that an “Issue” item can serve as a “canvas” for further art and craft. The units could be ganged as modules to serve as love seats and sofas, either in look alike suites or in eclectic manifestations of the expertise of Lunan artists.



Among the many possibilities are:

- ◇ aluminum panels embossed and/or engraved in abstract or pictorial patterns (“sculpsheet” alloy)
- ◇ textured metal panels including pyrited (fool’s gold) steel (brass or copper would be prohibitive)
- ◇ wire art
- ◇ wire weaves
- ◇ glass or ceramic beads strung on wires
- ◇ beads made from lunar rock
- ◇ macramé of fiberglass cords and ceramic and/or glass beads
- ◇ stained glass collages or murals
- ◇ glazed ceramic panels or tiles of varying sizes, colors and mosaic patterns

Nb. If any of these seem “heavy”, remember this is furniture for one sixth G or “sixthweight” and for the softer look

- ◇ fiberglass fabric carpet
- ◇ fiberglass bands in multicolored scotch plaid weave
- ◇ fiberglass fabric pleated panels

The vast variation in final appearances made possible by such a menu of possibilities yet maintains the common underlying shape of the parent “issue” item. Eventually, entrepreneurs would find ways to customize the lines of the piece as well, starting with the addition of decorative finials, head rests, hand grips, and swing-out foot rests.

Example: Chests and Dressers

A chest of drawers could consist of metal or glax drawers with a frontpiece frame to fill with matched or coordinated drawer front panels of choice, all in a metal or glax framework whose sides, top, and edges are again opportunities for optional embellishment. Drawer pulls of metal, glass, and ceramic add another avenue for variety. If in time it becomes acceptable to withdraw small amounts of wood at a premium price from the biosphere cycle, usual roles may be reversed: expensive wood handles and pulls adorning metal or glax chests, not metal and ceramic handles and pulls adorning wood cabinetry. Perceived value will follow bottom line expense.

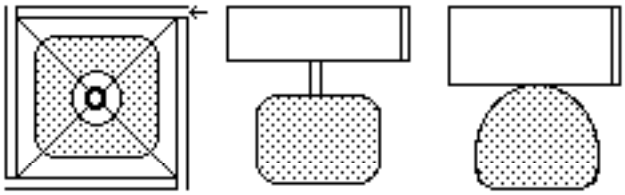
Example: Bed Headboards

Rectangular, Oval and other Headboard frames could support similar “panel” finishing. A large variety of choices exist. And of course, we could have bookcase headboards with built in drawers and doors just as easily as on Earth.

Example: Lamp Shades

Lamp bases can be of metal, glass, glax, ceramic, or some combination of the above. Glass, glax, and ceramic will offer the greatest opportunity for coloration. Design possibilities are virtually limitless.

For shades, translucent parchment and fabric materials other than fiberglass will be unavailable. Translucent, not transparent glass shades are a likely favorite. But so are pattern-pierced metal sheet, possibly also embossed. Following suite, one “issue” item may be a simple framework for supporting various slip-in diffusing panels. Stained and waterglass/oxide painted glass shades have ample precedent. Pleated fiberglass shades will be most reminiscent of current favorite options. Glass beadwork and wire creations are yet another possibility.



Above are overhead and side views of a schema for rectangular metal channel framework “shade starters” ready for slip-in panels of various materials, designs, and colors. There is no attempt here to predict style lines, only to get across how “issue” items can support the search for individuality and personal expression, as well as a thriving community of artists and craftsman entrepreneurs, all learning seemingly trivial but psychologically important ways to make the lunar setting a fully humanized one.

MMM

UPHOLSTERY FABRICS

UPHOLSTERY FABRICS

All this is interesting perhaps, but what about the need for visual softness, sound absorbency, and cushioning? We admit that we cannot be withdrawing vast amounts of natural or synthetic organic fibers from the Biosphere cycle, but ...! Available options are few: Fiberglass fabrics hold up well as long as they are left alone, i.e. abrasive contact is kept to a minimum. Thus fiberglass draperies, fiberglass wall carpeting, and fiberglass surround panels for box chairs, love seats, and sofas can be used to take care of the first two needs: visual softness and acoustic dampening.

As for cushioning, it is important to keep in mind that here in sixthweight the natural cushioning of buttocks, the soles of one’s feet and elsewhere on the body should be quite enough especially when combined with contoured form-following molded seating surfaces. Underfoot, it would be far more ef-

fective and economical to put extra cushioning in shoe soles than waste it profligately on the floor at large. But again, in sixthweight, there should be little need.

Special needs: pillows and mattresses

Ahah! Solve that one! It's not all that difficult, really. The upholstered foam and/or innerspring mattress which we now take as a standard is a relatively recent invention. For millennia, humans managed to rest and sleep under much less pampering conditions. The bed of hay, leaves, or grass; the cot frame supporting a woven or canvas sling; piles of spare clothing; the web hammock, etc. On the Moon, almost any form of nighttime cushioning will require some investment of flexible organic materials. Our task is to find a solution which offers acceptable comfort in sixthweight with minimal use of organics. The air cushion mattress scores vastly higher here than the upholstered foam lined innerspring. But the cot sling may work well enough in the light gravity for a large segment of the population. The sling can be a fiberglass weave covered with a cotton pad. Cotton, the organic fabric with the lowest Moon-exotic content (being fully half oxygen by weight), will be both the least expensive and the most comfortable fabric in all uses "next to the skin".

[Cf. "APPAREL: Everyday and Occasional Made on Luna Clothing for the Early Settlement" by Peter Kokh in MMM #13, MAR '88 and "THREADS" by Aleta Jackson in MMM # 5, MAY '88. - both republished in MMM Classics #2]

For head pillows, an alternative to rolled up clothing would be the cotton slipcovered baffled silicone air pillow. Where back problems mandate, even in sixthweight, mattresses of similar construction would be the least costly choice.

To encourage prompt recycling of discarded cotton apparel and fabrics, there is likely to be a very generous cash-in value, if not a weight for weight trade of old and new goods. For those wealthy enough to snub such strong economic incentives, such things as braided bedside throw rugs and cases and fill for bed and sofa toss pillows can be made of unused clothing, bedding, and toweling.

MMM

"No individual has any right to come into the world and go out of it without leaving something behind." George Washington Carver

SCULPTURE

Making three Dimensional Art Objects from Lunar Materials

Perhaps most people, thinking of sculpture, imagine a piece of marble being chipped away by the sculptor's chisel in search for the form "lurking within." In this classic but very narrow sense of the term, Lunan sculptors may be left out in the cold. The kinds of rock favored for sculpture on Earth just don't form on the Moon where the geological processes are quite different. Perhaps some types of unfractured lava stone may yield to carving, but the crude results will likely never match those achieved in marble, granite, jade, alabaster, soapstone and other prized rocks and minerals. One lunar-sourceable inorganic synthetic, fiberglass sulfur composite, is an untried possibility. [See MMM # 65 MAY '93 p. 6 "MOONWOOD" Republished in MMM Classics #7]

But sculpture, in the sense of any three dimensional art object, can also be cast. Cast basalt and unrefined glass will be the first media available. Gradually, as chemical engineers do their work to produce needed elements and chemical feed-stocks for Lunan industries, specially formulated pouring ceramics and refined glass will become available. As to cast metal, the traditional favorite, bronze, an alloy of copper and tin, will not be among the lunar-sourceable choices. Nor will copper, brass (copper-zinc alloy), pewter (tin-lead alloy), gold, silver, or platinum. Instead, only casting materials with much inferior "character" will be available: iron and steel, titanium, aluminum, and magnesium.

Metals, of course, can also be turned into sculpture by other means, principally machining and welding. Mold compacted and sintered iron fines may be suitable for some purposes. When it comes to welding, the lunar sculptor has an ace up his sleeve unavailable on Earth, the possibility of doing his craft outlocks where vacuum-welds may be achieved.

For cold-working, synthetic lunar clays made of hydrated aluminosilicates should be available fairly soon for the “potter”. Lunacrete, lunar concrete, is another likely sculpture stuff. In both cases, all the associated water of the “plastic” or “green” body is eventually released to the biosphere’s atmosphere, to be recovered by dehumidifiers. Gypsum plaster or plaster of Paris, however, must retain water of hydration and so will be an expensive option, without compensating quality.

Sculptures are also carved from organic materials such as wood and bone (ivory and scrimshaw). On the Moon, it is not likely the latter will ever be available except as heavily taxed imports. Wood will be so precious that it may well be a prestige jewelry stuff. In effect, good carving woods, perhaps derived from fruit trees, e.g. cherry, apple, pear and others, will share the niche now owned exclusively by gemstones. These in turn, except for synthetic corundums (a form of aluminum oxide) like sapphire and ruby, may not be found on the Moon.

In a broad sense, sculpture can also be “composed” by mechanical assembly. Metal parts, sheet, or wire as well as moon rocks like breccias could be used in this way.

The options are different, and fewer. But the Lunan sculptor will still produce creations of beauty. MMM

ON THE WALL

Part II: What to hang?

“Paintings”

As mentioned last month, LRS is sponsoring an effort to pre-develop a line of lunar-producible sealants, paints, and stains all based on Waterglass, sodium silicate hydrate, a liquid and the only known inorganic adhesive. We cannot predict results of our experiments and perhaps we will quickly reach some showstopper. But we have identified a local source of waterglass at only $10/gallon, and we do not anticipate much difficulty in finding local sources of lunar-producible metal oxide powders to use as tints and pigments. A tentative agenda of experimentation has been worked out but this will change, perhaps drastically, as we see how our concoctions behave. Meanwhile, let’s assume sufficiently favorable results to support fully lunar-appropriate painting art and craft.

The first thing a painter needs after his/her paints of course, is something to paint on. For wall hung art, that means a **canvas** of sorts. Among the lunar-producible, inorganic substitutes for common canvas that come to mind are:

- ◇ opaque glass (front-painted)
- ◇ ceramic tablet or tile
- ◇ metal sheet
- ◇ stretched, waterglass sealed fiberglass fabric Nb. if this application is brittle, then the fabric may need to be stretched over glass or metal support sheet, not just stretched over a hollow frame.
- ◇ back-painted clear glass
- ◇ back-painted unbreakable glax (glass glass composite)
- ◇ vitreous glazes on a ceramic tablet, or tile mosaic

For mass production, once a master has been made or designed (on a computer), computer run machine produced art is a possibility. But given the small market and the need to have something different from the Joneses, the market share for items like this seems small except for cliché paintings of the Earth, settlement site panoramas, and a few other subjects.

Next the painter (or the gallery) will want a **frame**, and possibly **matting**. Glass, Glax, ceramic, and metal frames are possible and may well be mass-produced in stock sizes with pre-drilled top-center hanger holes. Besides the common flat frames, there could conceivably be exterior hull wall contour-following cylindrically or spherically convex frames and can-vas substitute painting boards, as a specialty item. Fiberglass fabric covered metal strips in stock sizes may do for matting.

Pictures and Portraits

Portraits may be "painted" using the methods and materials suggested above. They can also be etched on glass or metal, or beaten, bas relief style, in a malleable metal sheet. **Photographs**, however, are a more problematic subject. Cameras will likely be expensive "upports" from Earth for a long, long time. Ditto with film. You can choose to think the settlers will be affluent enough to make Earth-style photography as common a hobby on the Moon as it is here. I think not. Perhaps a few who do weddings and other special occasion work could make a go of it, but their fees and prices will have to be quite steep. What about a lunar solution? Film substrate is one problem, photosensitive coatings are another (you can forget about silver). If inventors and entrepreneurs could come up with some ingenious lunar substitutes or hybrid lunar-terrestrial solutions intermediate in price, then "standard" camera cases could be locally produced of metal or Glax, to be fitted with optics assemblies upported from Earth, a so-called "MUS/cle" solution. This is really the topic of another article, and yes, MMM is looking for a volunteer to do the research, or assist in doing it. Anyone?

Other wall hung items:

Ceramic and **cast basalt** bric-a-brac items should be fairly inexpensive, depending upon the glazes and special art finishing used. Glass and/or ceramic **Beadwork**, American Indian style or other, using woven fiberglass threads or thin wire, should reach a new popularity. **Macramé** using similar materials with fiberglass cords, or conceivably rescued twine used in packaging sundry items shipped to the Moon, could be another standby.

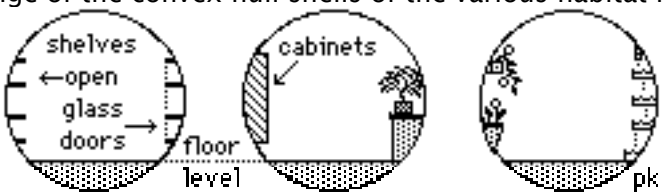
An **aluminum** alloy can replace copper as a medium of wall hung **metal sculpture** and bas relief work. **Wire Art** creations are another easy medium.

Fiberglass tapestries, perhaps with embroidered panels using fiberglass threads of various color stains may be possible. However, fiberglass threads are rather brittle compared to cotton and nylon, as well as potentially irritable to the hands of the artist. Experimentation to devise workable methods for such a craft will be needed.

Stained glass art panels suggest themselves, but do take note of one problem. The caning in universal use to create the cartoon lines of common stained glass mosaics is made of lead, which is most unlikely to be available except at a very dear price. Are their other lunar-producible sufficiently malleable alloys which can be used? Or might the artist bond the individual pieces to a piece of clear substrate glass, perhaps using sodium silicate as an adhesive?

Wall lamps, sconces and wall washers with glass or metal light diffusers or shades should be common enough.

Knickknacks, **shelves** and shelving could be made of metal or Glax (glass glass composite). Some wall-hung curio, display, and other type cabinetry and shelving systems may be custom designed to fit the middle height range of the convex hull shells of the various habitat modules.



Wall hung **planters** of metal, ceramic, or Glax, even **fountains** and water cascades may adorn convex or flat walls.

In short, Lunan Homesteads may be as rich in wall-hung items, both functional and beautiful, as homes Earthside. The choices will be meager at the start, of course, but quickly expand as entrepreneurial art and craft cottage industries spring up, their creations sold in weekend streetside bazaars.
MMM

"Art du Jour"

Temporary Creations of Lunan Settler Children made of organic craftstuffs from farm & garden, and meant, with rare exceptions, to be recycled

Relevant Readings from back issues:

[Republished in MMM Classics #3] - MMM # 22 FEB '89 p. 6 "HAIR" - MMM # 26 JUN '89 p.4 "TOY CHEST"

[Republished in MMM Classics #4] - MMM # 34 APR '90 pp.5-6 "The Fourth R"

To foster artistic talent in the young, it is important to supply them with "play-media" upon which to exercise their talents. For this purpose, organic stuffs derived from garden and farm might be permitted a short-term detour en route to their recycling back into the biosphere via biodigesters or other routes. Natural dyes can serve to develop painting talents upon easy-to-recycle simple recyclable papers. Potatoes and bars of soap can help develop carving talents. Beeswax and putty made of flour, water, salt, and baking soda can stir in them the talent of the potter. Corncobs, husks, seeds, kernels, nuts, eggshells, peanut shells, bones and even hair clippings are things with which to make dolls, toy characters, and other "neat stuff".

Parents proudly display their children's creations, and often put them on display where they will be noticed by any visitors. But save for exceptional samples, most of these loose whatever encouragement value they may have rather quickly, given youngsters' usual swift progress. They can then be recycled back into the biosphere, having served their purpose. Eventually, those who have displayed talent worth encouraging further can be weaned from these media, graduating to the inorganic art media that can be supported by the settler economy, reliant on local resources.

In addition to organic stuffs for "art of the day" creations, school students may have access to sundry other items at the start of the recycling pipeline. Sculpture made from scrap metal, glass, ceramics, and other inorganic materials, if prizeworthy or salable, can be left intact permanently with little or no ill effect on the economy.

And if, as we've suggested, older children are charged with the creation and production of toys for younger ones, this may develop their entrepreneurial talents as a bonus. MMM

Homestead Furnishings & Decor

Cottage Industry

As we suggested in MMM # 75, one of the reasons to build settler homesteads in a generously pre-expanded form, (the concept of the Great Home) is to allow room within for the birth of cottage industries. In the early settlement period, the worktime services of almost everyone will be needed to support the biosphere (food production, recycling, etc.), export trade, and manufacture of basic needs (shelter, some basic furnishings, "issue" clothing, etc.). The need to reach real economic break-even and then go on to economic profitability i.e. a positive trade balance with Earth, as soon as possible, will be the governing fact of life for a long time. To the extent that this condition still prevails, the only labor available for the creation and production of "luxury" items, from personal touch clothing to customized furniture and art- and craft-rich furnishings will be the spare time after hours of those who have both talent, leftover energy, and the entrepreneurial soul.

This activity deserves to be supported because the morale of everyone stands to benefit. One way to effect this would be for the settlement government to "subsidize" the import of special needed tools to be owned by cooperatives of artists and craftspeople on a time-share basis. The individual cooperatives, or even a union of cooperatives, could schedule training classes in tools, materials, methods, marketing, joint ventures, etc. A publicly owned complete library of terrestrial folk and ethnic arts and crafts of all types would serve the settlement well. For many such historic arts and crafts may prove to be inspiring models of resourcefulness.

Once a "University of Luna" has been established, an Extension Service to Cottage Industries ought to be an early priority. For today's cottage industry serving local needs may someday grow and evolve into tomorrow's exporter. Surely such cottage industry will be a prime wellspring of economic and industrial diversification.

This is not to ignore the harsh fact that the transition from home-nested spare-time money-making hobby into a true independent small business is difficult and fraught with risk. Again, govern-

ment and university services should be available to help those willing to take the plunge. Others will be content to continue operating as a part-time at-home hobby for fun and spare change, and they should not be discouraged. MMM

[Pioneering a Moon-appropriate art medium]

waterglazing

R&D Report: #1 — 6/22/'94

A Lunar Reclamation Society-supported **project to attempt to develop a lunar-appropriate "painting" medium** has at last begun. The seminal idea arises from the fact that waterglass, a hydrated sodium silicate (and a chemical cousin of ordinary garden variety window glass) is **the only known "inorganic adhesive**."

There the idea lay, germinating, for several years until last May 3rd when we learned that a local Milwaukee pharmaceutical supply house, Laabs, carried sodium silicate for $10 a gallon. When shortly after that MMM received a $50 donation from Glen P. Wilson, NSS Executive Director Emeritus, the LRS board agreed that this ground-level R&D project would be a fitting place to invest it.

The lightbulb idea is that **perhaps we could paint with metal oxide powders suspended in a waterglass medium.** Peter Kokh is the experimenter.

Purchasing the needed materials

On June 16th, we bought a gallon of sodium silicate. We applied some, as is, with an ordinary brush, to a brick, a terra cotta flower pot, a glazed pot, and to pieces of glass, aluminum, and sheet metal. The brush cleaned easily in water. The waterglass dried within an hour on all items, beautifully varnishing the brick and the terra cotta pot. It "skipped" somewhat on the metal and glass surfaces but still had a high gloss.

The next day, we took the sheet metal piece and put it under a stream of warm water, rubbing vigorously. The Waterglass "varnish" dissolved and washed away. On the other hand, we sprayed the glass piece with Windex and wiped it clean, with no apparent loss of the "waterglaze". This would seem to place some limits on its usefulness, but limits we could live with. For example, if the home had "trimwork" around doors and elsewhere of unglazed ceramic tiles, these could be water-glazed. When dirty from hand soil, they could be easily washed clean and reglazed. Meanwhile, art objects painted or glazed in this medium, and safely out of harm's way, should endure indefinitely, even with occasional gentle cleaning.

The next day, we baked the aluminum sample in a 250° F oven for about half an hour. The waterglass lost its glossy appearance and "crystallized" to a whitish color, still adhering firmly to the substrate in the pattern in which it had been painted. The effect seemed rich in its own right, and suggests that metal might be decorated with either "baked" or "unbaked" waterglazes. Baked on the reverse side of glass, the effect is rather reminiscent of glass etching.

So much for the first round.

Our plan is now to get some colored metal oxide powders and start mixing. Different mix ratios will be tried for each oxide and the effects noted. In addition we plan to apply plain unmixed waterglass to various substrates and then sprinkle oxide powders on them, in effect "flocking" them, in various patterns. And we intend to bake some of the results.

We would also like to find lunar-producible inorganic powders which prove soluble in waterglass in addition to those forming suspensions. We'd like to come up with a serviceable spectrum of hues in both opaque (paint) and transparent (stain) varieties. We intend to religiously avoid any organic additives, dopants, or pollutants of the product preparations.

So far, while only the first step has been taken, the results are rather encouraging, our instinctive hunch verified. Our long term goal is to produce "Waterglazing Kits" to sell (at a modest markup to enable further experimentation) to those with real artistic talent. It is only in this way that we will see

what this new infant art medium is really capable of producing "in full flower". Sponsored competitions timed with the annual ISDC would be helpful in supporting such an outcome.

While our ultimate purpose and ulterior motive is to put "on the shelf" a ready-to-go lunar-appropriate art medium with which artistic settlers might humanize their homesteads, we fully expect some terrestrial artists to make real money selling their waterglaze creations near term on terra firma.

If you would like to participate directly or indirectly in this "colorful" little R& D project, please call or write:

Peter Kokh, 1630 N. 32nd Street, Milwaukee WI 53208-2040 (414) 342-0705 - kokhmmm@aol.com

Additional donations cheerfully accepted! Please make payable to LRS but note on the memo line that your donation is for the "Waterglass Project". PK

MMM #80 - November 1994

Pioneering a Moon-appropriate art medium

WATERGLAZING

R&D Report: #2 — 10/13/'94

Peter Kokh, Initial Investigator

The high gloss varnish effect I had reported, applying pure waterglass (sodium silicate) to an unglazed brick, proved to be temporary. After about 2 weeks, the waterglass coat started to crystallize, slowly becoming flat and whitish. Yet the lunar simulant/waterglass suspension I had applied as a first proof-of-concept "paint" continued to be bonded securely to the brick. So waterglazes are flat after all! Yet, I suspected that if one were to paint on the reverse side of a glass pane, the painting would be effectively glossy when viewed through the glass. This would turn out to be the case.

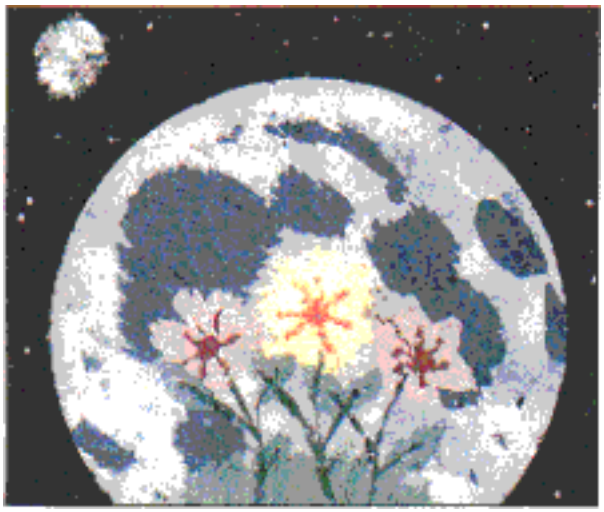
Slow Palette Development

During the months since the first report, the chemist at Laabs, Inc., Tom Volkman, took an interest in my project and spent some time finding suitable powders, given the list of lunar element abundances I furnished. These included ferric iron oxide (rust), titanium dioxide (white), manganese dioxide (black), and sulfur (yellow). A second pass through his source books yielded chromium oxide (green). All of these worked well, by themselves or in mixed shades.

But three powders he found for me flunked the test badly, instantly coagulating upon contact with the waterglass, even producing noticeable warmth: chromium trioxide (magenta), nickel sulfate (turquoise), and potassium chromate (bright yellow). Perhaps other peroxides and salts will prove unsuitable as well. And that may severely limit the possible palette. To date I have no real red, nor a blue, the latter missed most of all. Other chemicals I might try (vanadium and cobalt compounds are likely sources of blue) are even more expensive.

Lunar settlers will be able to "paint" using only materials derived from the regolith soil around them!

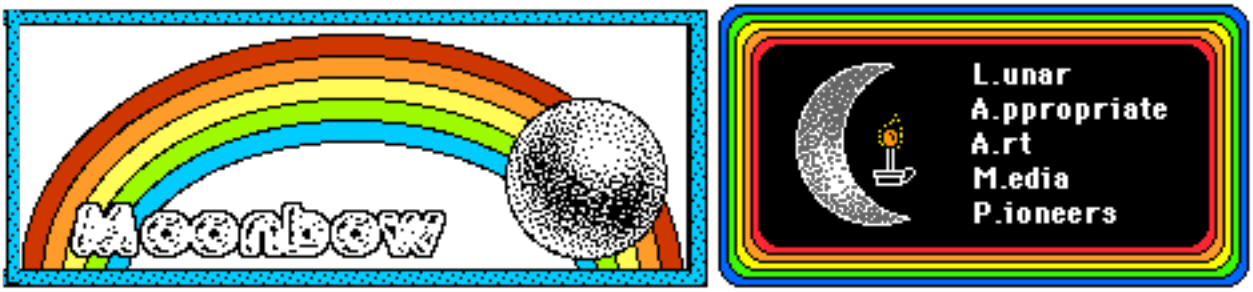
The first ever Lunar Style "Painting"



Above is "**Moon Garden #1**", reverse painted on an 8"x10" piece of glass, by MMM Editor Peter Kokh. The "paints" are not solvent based and incorporate no organic substances even as additives. Instead an inorganic adhesive (the only one known), sodium silicate is used to suspend either raw regolith powder or colored metal oxide powders. The palette is still limited and the art form undeveloped. More candidate lunar-sourceable colored powders are sought, as well as other artists, with more real talent to push the new medium to the fullest. More below.

Spurred on by an opportunity to display some concrete artwork, I conjured up a composition that would use all of the shades I had to work with, executing the piece Moon Garden #1 on the morning of September 30th, 1994 just in time for it to be displayed in the art show at First Contact, a new science/science fiction convention in Milwaukee.

The painting was done on the reverse side of an 8x10 glass. **Thus the foreground had to be painted first.** The subject is a stylized full Moon against the backdrop of space, a full Earth in the right upper corner. In the foreground covering the lower half of the Moon is a cluster of flowers, leaves and grass.



The upcoming Midwest Space Development Conference in Cleveland, Ohio (Oct. 14-16) served as stimulus to produce two more "demo" works.

"Greening the Gray" (taken from the refrain of a Lunar Frontier anthem I'd composed and published in Moon Miners' Review #7 AUG '90, it has a moonscape painted on the back side of an 8x10 glass, representing the past through the present, and a meadow and pine tree grove painted on the front side, representing the "surreality" of Lunar reclamation to come.

"Heinlein Roses" is a settlement "still life" painted on a 6x6 unglazed tile.

Waterglaze paints will work on metal as well, if the substrate is thick enough not to flex. And they could be used to decorate mirrors. The paints are mixed as needed, for waterglass suspensions dry and harden quickly. Small paper bathroom cups serve for mixing the suspensions, a turkey baster works to dole out waterglass in amounts needed. Still ahead are experiments with lunar-appropriate applicators: pads of steel wool?, of fiber-glass?, brushes of human hair?

Purposes of this Project

√ Develop a new art medium, one that lunar pioneers can use. At first actual settlers will use the raw "moontone" gray hues of unprocessed regolith, and perhaps glass microspherules sorted

out from the moondust according to shade. In contrast the "processed" oxide palette will grow slowly. Meanwhile, lunar habitats and homesteads will start to look and feel "at home".

- √ In the process, develop a new art form that is valid in its own right, whether the space frontier is settled or not. Thus earn income for terrestrial artists. Waterglass paintings will make great space center gift shop items.
- √ Produce a public body of work which will concretely illustrate how lunar entrepreneurial self-reliance can work to make an alien environment into a human one, bringing the feasibility of lunar settlement to life in one small vivid way.

Hopefully, the word about waterglazing will spread and others will join in the fun. Once this effort is well under way, perhaps a similar parallel endeavor can be launched to play with lunar-appropriate ceramics, and art glass. If you are an artist or know someone who is, please help spread the news. **PK**

MMM #91 - December 1995

[Pioneering a Moon-appropriate art medium]

R&D Report: #4 — 11/05/1995

WATERGLAZING By Peter Kokh, amateur artist

RECAP: This is a "Lunar Arts/Craft" R&D Project aimed at determining if "paints" suitable for use by artists in a pioneer settlement can be made entirely from elements recoverable from lunar regolith soil. The idea is based on the fact that sodium silicate, commonly known as "waterglass" and a liquid at room temperatures, is the only known inorganic adhesive. It can be produced from lunar soil, and the basic experiment is to see if adhesive-based (rather than solvent-based) "paints" can be made by mixing in colored metal oxide pigments.

The first painting, Moon Garden #1, was produced 9/29/'94 using sodium silicate, titanium dioxide (white), manganese dioxide (black), ferric iron oxide (rust), chromium oxide (green) and sulfur (yellow) and combinations of these to produce gray, orange, and pink. The "canvas," again picked because it could be produced locally in a lunar settlement, was glass, painting, foreground first, on the backside.

An article about the project appeared in the Jan/Feb '95 issue of **Ad Astra**, pp. 46-7. Since then other pigments have been tried, not all successfully. The most notable (and costly) addition to the palette being cobalt aluminate blue.

The Aging Problem - Worst fears allayed

In a few months, the first two paintings had begun to show patchy delamination from the back surface of the glass. The prime suspected culprits were low winter indoor humidity, a film of windex on the glass, or, worse, a temporary aspect to the adhesive quality of the medium. The third painting, done in mid May addressed both the first two concerns. The pane was baked after cleaning to remove residual windex film. And the air was now more humid. Six months later, this painting looks much as it did the day it was produced.

While this allays the worst fears, that waterglass painting may turn out to be suitable only for "temporary art," we are not ready to claim that the problem is solved. This is an experiment, and it is the nature of experiments that sometimes the desired result is not, even cannot be, produced. Time alone will tell whether or not this "aging" will continue, whether or not it can only be postponed, etc. We will not resort to organic additive "fixatives" as this would invalidate the experiment.

> **[Note: Fast Forward to 2010** - at the suggestion of a Green Bay, Wisconsin glass artist, we tried again, this time painting on the side of a glass pane that he had sandblasted for me "**to provide some grip.**" This worked! **Problem Solved!** - PK

New Pigments, methods tried

In the past several months, some new pigments have been purchased. Iron Sulfide, FeS2 (fool's gold), yielded disappointing results. Vanadium Pentoxide, which promised a bright golden orange joined the ranks of three previous "failing" pigments in immediately reacting with the waterglass and gumming up. Chemicals that had not worked now represented an investment of well over $200. However, a somewhat crude "work around" application method promises to recoup some of this investment and expand the palette. We have succeeded in "flocking" one of these four powders on glass wet with plain waterglass. Potassium chromate gives us a brighter, more vivid yellow than the pastel sulfur we've been using so far.

New paintings, sales, gifts, donations

This fall saw three more paintings. "Out the Window" depicted an oval window in a lunar habitat, looking out on the Moonscape (painted on the reverse side of an 8x10" pane) with the peripheral foreground inside the habitat painted on the front side of the glass. It was donated to Greg Bennett, CEO of the Lunar Resources Company and chief architect of the Artemis Project™ – after hanging "NFS" [not for sale] in the First Contact II art show. Also in the show, up for bid, was "Earth in Space" painted on the reverse side of the 8x10" glass, with however, the clouds on the front side of the glass to create depth and show that they were not Earth surface features. This went for $60. A small 5x7" demonstration piece, "Moonscape" was donated to the charity auction and went for $12. The following week, the second painting produced (mid-October '94) called "Greening the Gray" was donated to the MSDC seed money raffle. Meanwhile, membership in L.A.A.M.P./ subscriptions to semiannual **Moonbow** [no longer avail-able], crept up to just ten.

Waterglass-aided Stained Glass Experiment

We hope to soon begin diversifying work with water-glass. Stained glass (art glass) is certainly a viable lunar art-form, materials wise, with one exception: the "leading" that separates/joins the individual colored glass cartoon pieces. What we want to try is cementing these colored glass pieces, using waterglass as an adhesive, to a host transparent pane, filling the gaps with a thick paste made of waterglass and common regolith simulant. The look should be similar enough, and the heavier pieces will be lighter in lunar gravity. PK

MMM #92 – February 1996

PIONEER HOLIDAYS

and other festivities

By Peter Kokh

While "new traditions" (as oxymoronic as it sounds) are being made all the time, there is little doubt that those that command our observance most deeply are those which are oldest, rooted in our collective gitgo times. So it is with Holidays: Christmas, Easter, New Years go back millennia (two at least). Thanksgiving goes back nearly four centuries. The 4th of July will be 220 years old next time around.

We can expect that as the lunar frontier becomes fully established with the coming of age of the first native born generation of Lunans, the holidays and festivals they will most cherish will include those observed by those establishing the first beachhead.

The Apollo 11 landing (July 20th) is sure to be observed, as is the "infamous" day of retreat, the liftoff of the Apollo 17 crew (December 10th). But neither of these "trivia" dates will rival the enthused

celebration of the **"Day of the Return"** when humans come back to the Moon intent on setting up an open-ended "permanent" presence leading to genuine settlement.

The first crew may only set up camp and then return to Earth, to be followed by the first crew intent on staying a full day-night cycle (the lunar "sunth)" or more. So closely connected with the observance of the Day of the Return will be the celebration of that first successful "overnighting" and the greeting of that first "sunrise" - **"First Night's End."**

Finally, **"Ever Since Day"** will mark commencement of uninterrupted human presence on the Moon. If I were to put a friendly wager on which of these will be the most honored in Lunan settlement tradition, it would be on "First Night's End." There will be a special flavor to this holiday, the shared mutual congratulations at having survived this "initiation" imposed by the Moon itself. And for all non-native born Lunans, there will be a special personal resonance with memories of their very own "First Night" and "First Night's End."

Other history-rooted anniversaries may mark the birth of the **first native born** Lunan. And later, the first native born grandchild (i.e. second generation, whose health will be the final test of whether or not humans can stay on the Moon indefinitely) [See MMM # 47 JUL '91, p. 5 "Native Born"]

Not all Lunan Holidays and festivities will take root in such historic occurrences. Some are sure to be bound up with the **Moon's natural rhythms**, much as a growing minority of us terrestrials observe the equinoxes and solstices. Local **sunset** and local **sunrise** will be big deals, something to mark with a special meal or wine or friends - simply because they occur on a 28+ day cycle, not a 24 hour one.

If a particularly appropriate **Lunan Calendar** is adopted [see MMM # 7 JUL '87, "Moon Calendar" - republished in MMM Classics #1], with "sunths" of 28.5 (24 hr.) days instead of 30.5 day calendar months, with the discrepancy with Earth reckoning made up with occasional "leap" ("intercalary)" "sunths" or weeks, Lunar New Years may only approximate the fall of New Years on Earth.

In such a case, the observance of religious feasts and holy days may also vary with that on Earth, without spiritual harm to those who honor them. This will be much to the chagrin and resistance of religious fundamentalists (those who give major importance to the minor, and minor importance to what really matters, and call every one else heretic and infidel.]

Solar Eclipses on the Moon are the flip side of Lunar Eclipses on Earth. They will be much more of an experience for Lunan pioneers and settlers than any eclipse on Earth (even total Solar). They will last several hours locally, and possibly may occasion the morning or afternoon "off" (work or school) as the case may be. And it will be the most favorable time for looking for city lights on Earth's nighttime face.

In time, other **"political" milestones** will come to be honored in settlement tradition - the day when home rule is won, or independence declared, for example.

Historic and festive holidays will not be the only early-rooted traditions. **Pioneering songs and ballads**, even candidate settlement **anthems**, are sure to be written, sung, performed, and loved.

There may arise too special **festive foods** with historic significance. We have pretzels and cross-over buns associated with Lent, unleavened bread associated with Passover. Eggnog, Christmas cookies, Easter Eggs, Pumpkin Pie are among many foods especially popular at specific festive times. On the Moon, many long-loved foods and recipe delights will not be available early on. Special early frontier substitute food and menu items, beverages too, even if in time the need to make such substitutions eases, may be prepared and consumed with relish on commemorative occasions. Associated with such holiday tradition meals may be time-revered toasts, blessings, and mutual greetings.

Certain **plants** are associated with various observances on Earth; poinsettias and mistletoe with Christmas, for example. And plants grown successfully in the early outpost days may come to be associated with various Lunan observances in like fashion.

The first humans to return to the Moon may think that all they are doing is erecting, deploying, setting up, demonstrating, testing, etc. But even the little incidental things they do, may in time take on special meaning and color not at all obvious at first, to become ritually repeated. This will all occur sometimes spontaneously, other times with alertness, if not deliberateness, as a part of fulfilling the very human need to impose on nature's own rhythms, a festive and commemorative **cultural rhythm** of our own. Such cultural rhythms are a major element of the **social glue** that binds generations together.

In this way they will bind future Lunan generations, much as similar traditions have always served in terrestrial communities throughout the globe, and throughout historic and prehistoric times.

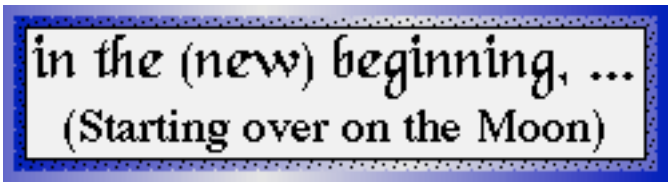
MMM

MMM #94 - April 1996

The Cultural Implications of the Moon's 1/6th G

This month, we return to our essay series on the early days of a permanent human community on the Moon, as we at the **"Lunar Condition,"** the defining set of parameters that go with the territory and will leave an indelible mark on early Lunan culture and civilization. The Moon is a world dramatically different from Earth. One way this was brought home to hundreds of millions was the sight of our astronauts and their moon buggies bounding and bouncing about in the lower gravity. The effects of "sixthweight" will be more than anecdotal. For the impact of the Moon's environment on pioneers, see below.

[Continuing a New MMM Series]



The primitive roots of "Lunan" Culture

This month we return to our series of essays on the very early lunar frontier. It may at first seem that a particularly "Lunan" culture will be a development a long time arriving. On Earth we are used to considerable cultural diversity, both from place to place and through the generations. It may seem outrageous to forecast the day when we will see revealed the considerable family resemblances all terrestrial cultures bear to one another. But there are certain time-and-place-transcending aspects of Earth that insert themselves in every human culture to date. For whatever the differences we love to exaggerate, we all share one very friendly planet, one encradling biosphere, the same gravity, the same protective envelope of sweetened air in which we work and play under wide open blue skies.

The unique equally transcendent wellsprings that will eventually make "Lunan" culture distinctive from all terrestrial cultures, making it in effect the first culture of a new family, will be present from the outset, intensely felt already by the first crew to take the plunge and "overnight" on the Moon.

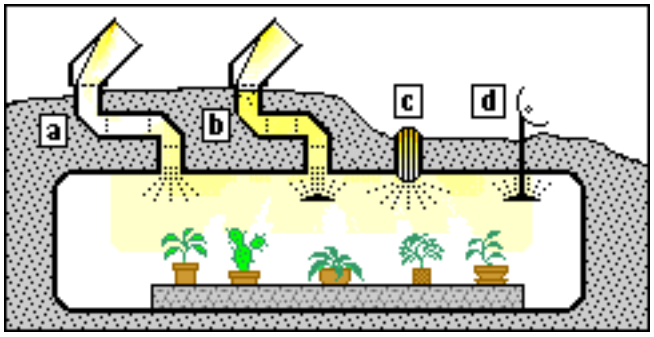
The Moon is a world dramatically different from Earth. It's gravity is only one-sixth "normal." It is without atmosphere of any practical consequence. Its surface lies naked, exposed to the weather of space. It offers no life supporting biosphere of its own. These constraints will make life-as-we-are-used-to-living-it a memory-myth early left behind. As we deal with these facts and their consequences with a swim-or-sink urgency, and as we find successful ways to accommodate them, we will be forthwith face-slapped out of any romantic reveries we may have had. — this month's topics.

So much for day one! Hardly will we have begun to cope and neutralize these brutalities and two other facts about the Moon will carve nascent Lunan culture even more deeply. The Moon is very dry. And its mineral assets lack some of the industrially strategic elements Earth's more generous endowment has lulled us into taking for granted. — next month.

We have touched on each of these topics before in sundry articles. We do so again, all in one place, from the eye of the future historian and anthropologist interested in the very early beginnings of what is sure to develop into a uniquely Lunan culture and civilization.

There will, of course be many other things that add color to lunan culture. The sports that arise, for one thing: indoor, middoor, and outvac. Trade relationships and particulars with other off-Earth pockets of humanity throughout the Solar System. Political events. Art and Literature. The performing arts and media. And, of course, the indelible mark of powerful and influential personalities. But all these things will but add flesh to a cultural infrastructure grounded in the physical nature of our host adopted world, the Moon. And this infrastructure will fall into place almost immediately. MMM

MMM #96 - June 1996



A Green Security Blanket

How will outpost personnel on the Moon for long tours of duty, and eventually Lunan settlers intending to live out the rest of their lives, cope psychologically with the unending and unrelieved stark and barren moonscapes? Whether traveling on the surface or looking out a habitat view port, they will never spot a stitch of chlorophyll green, of plant life, not even as humble as moss or lichen or slime. We can expect that they will compensate with an unusual abundance of house plants - by our standards. See below.

Against the Overwhelming Barrenness of the Moonscape

By Peter Kokh

Relevant Readings from Back Issues of MMM

MMM # 8 SEP '87, "Parkway"; "Animal Life" - MMM # 50 NOV '91, pp 8-9. "Trees"

MMM # 53 MAR '92, p 6 "Xititech III. Cellular Rhythm" - MMM # 54 APR '92, pp 5-6 "Xitiplans"

MMM # 76 JUN '94, p 1 "Windows, in with a new cliché"

[**NOTE: "Xity, Xities:** Beyond-the-cradle off-Earth settlements ("Xities") (pronounced KS not EX) will be fundamentally different from the familiar Biosphere- "l"-coddled "cities" that have arisen over the ages to thrive within the given generous maternal biosphere that we have largely taken for granted. Elsewhere within our solar system, each xity must provide, nourish, and maintain a biosphere of its own. For more, visit the MMM Glossary at:

http://www.moonsociety.org/publications/m3glossary.html]

Some of us are house plant nuts, some of us are hobby gardening enthusiasts. But perhaps most of us don't give vegetation, indoors or out, much thought. We don't have to. Given the general luxuriant feel of the outdoors, we get enough of a green-fix automatically without having to concern ourselves much about it. And that remains generally true, even in this era in which the health of the host environment is in question, and living nature under siege from selfishness, greed, and simple carelessness.

On the Moon life is not a given. There is none of that comforting green stuff maintaining itself on automatic. The outdoors is lifeless, barren, sterile - relentlessly so - assertively so - threateningly so. Greenery within the protected confines of the mini-biosphere will become a preoccupation of all but the most soulless personalities.

That a healthy abundance of plants contributes significantly and noticeably to air quality and freshness will be a reinforcing motivation. (NASA-funded studies have shown that the right mix of houseplants can be quite effective in reducing household airborne pollutants.) But we suspect that for most Lunans, the real driver will be the need to use plant life as a security blanket, a psychological filter against the out-vac's life-quenching sterility, much as for smokers, a cigarette makes the world a friendlier place (no, I am not one).

If lunar homes and offices and schools have windows affording moonscape views, inside window box planters of houseplants will take the edge off the life=threat of that magnificent but deadly desolation. But we will find many other nooks and crannies to put plants. Greenery and foliage will become the mainstay of interior decoration. Everything else will play but a supporting role.

A much higher percentage of Lunans are likely to be home gardeners. They will be aggressive in finding opportunities to add plants. Quite possibly a solar-lit atrium space will become the organizing focus of choice in purchaser chosen home plans. Such a space will afford vegetable and herb gardens or a mini-orchard to help with the food budget and menu variety, maybe a tad of entrepreneurial canning. But it could also be devoted to purely decorative plantings of variegated foliage and flowering plants, song birds, hummingbirds, and butterflies. Or it could become a more mystical place, a Japanese style sand and stone garden. For despite the general preoccupation with plant life, there will still be a big range of personal sensitivities, and of lifestyle needs.

Architects in general will look for ways to build-in planters and other cubbyholes for plants, providing also for their illumination. Vegetation will be a new design parameter.

Out in the "middoors" too, every opportunity to tuck in vegetation will be aggressively pursued by architects and users. Middoor streets and passageways, intersections and squares, are likely to become as verdant as they are busy. This can be the concern of the xity (SEE NOTE) administration, or, more healthfully, of rival neighborhood, and street merchant associations, or other stretch-"adopting" clubs. (NOTE: "XITY' is a term we give

While green will be the dominant color thus inserted into settlement life (architects and decorators will be motivated to find ways to introduce ambiently lit sky blue ceilings and open space sky blue vaults), settlers may rely on plant life to provide other colors as well. The early lunar art pallet (water-glass-based metal oxide "paints" and ceramics) will be one of generally subdued colors. As helpful as such additions will be, the thirst of the more vivid coloration of flowers (and perhaps birds and butterflies) will be strong.

It is likely that flowering plants will be staggered so that at least something is in bloom every sunth (the lunar dayspan / nightspan cycle). Will flowering plants grow taller on their own in sixth-weight? Or can they be coaxed to grow taller? If so, Lunans may be able to savor the delight of floral "forests." These would provide a must-see tourist draw.

Trees are likely to be of the dwarf variety (many fruit-bearing dwarf hybrids are already marketed), more bush-like in size, at least until the cost of imported nitrogen makes economically feasible the construction of higher-vaulted middoor spaces. In the meantime, to fill the void, individuals and clubs may take strongly to the cultivation of bonsai trees, even to the point of growing bonsai forests, again a tourist must see.

The first parks may be interim floral and grassy meadow refuges within agricultural areas. Even if the farm units are highly mechanized assemblages of trays and racks and LED lighting arrays, the sight of so much greenery (and the freshness of the air) will make any kind of food-producing area a mecca for those living or working nearby.

In the previous article, we mentioned that minibiospheres will guarantee the reintegration of city and farm, the overdue return to farm village roots and a more nature-harmonious lifestyle-paradigm.

Already in this century here on Earth, most developed cities have thinned out greatly in density, giving much more space to greenery (even if still more to pavement, in homage to the great god Auto).

Also on Earth, we have seen a general increase in urban and especially suburban wildlife, a welcome turnaround, led by post-human species, species that have learned to thrive in human-dominated environments. We can hope that Lunans will indulge in the luxury (to bean counter eyes) of urban wildlife. We've mentioned birds and butterflies. Surely bees, ducks, swans, flamingos, squirrels, even deer, and more.

In our cities, pockets of life are seen as a concession to nature. In the off planet xity, pockets of humanity will be the concession. Vegetation will play the host. The Xity will be an exercise in symbiosis, man and Gaia reunited. MMM

ABORIGINAL AND STILL ONGOING PRODUCTION OF GLASS FROM MOON DUST

By Peter Kokh

Foreword - "Natural Production" on Earth

"Manufacturing" is increasingly a strange word, for literally, it means "made by hand." Yet more and more the involvement of human hands is reduced to pushing buttons, sometimes just on a keyboard. But behind the "manu" is still the "mente," the mind. In that sense, we can hardly speak of Nature manufacturing anything. Yet "natural production" of many useful things does occur, and the historical foundations of human economies are rooted very deeply in these natural productions, as opposed to purely human manufacturing. It is very much as if human industry relies on recipes using "not quite from scratch, prepared ingredients." All you fellow bachelor chefs know of what I speak.

Our terrestrial economy owes a great debt to the natural production of sand and gravel, marble, granite, slate, and veins of concentrated metal ores. These handy prepared materials have been naturally produced through the eons by geological processes. And of course, where would we be without those biologically assisted geological processes that have resulted in the natural production, and warehousing, of limestone, chalk, coal, oil, gas, shale, and other fossil derivatives? "Natural Production" - if you will not admit "Natural Manufacturing" - has given our species an enormous handicap, without which, for all our pretentious brainpower, we might still be in the caves or in the forests.

"Natural Production" on the Moon

On the Moon, these particular natural productions have not occurred. Luna is geologically dead, and has been for a long time. That said, Nature is still very much alive on the Moon, and busy, in a way we are sure to find very helpful.

Our outpost construction efforts, at least long term, stand to gain from the natural production of craters, rilles, and lavatubes. When it comes to future production of building materials and processing in general, while the chemical and mineral assets of the Moon would seem very homogenized in comparison to those of Earth, there has been some helpful beneficiation and enrichment. Highland soils are richer in aluminum, magnesium, and calcium. Mare soils are richer in iron and titanium. The splashout from the Mare Imbrium impact event is enriched in the so-called KREEP deposits: potassium, rare earth elements, and phosphorous.

More, we suspect the as yet unsampled central peaks of large craters represent upthrusts of deep mantle material; and that may prove a useful starting point in the production of some useful chemical elements. Finally, we have hope that some of the crater impacts were caused by asteroids rich in elements otherwise scarce on the Moon - like that which caused the Sudbury, Ontario astrobleme, source of much of the world's nickel and copper.

Regolith 1.03

1.00 Nor does the list of prepared lunar assets stop there. Incessant meteorite bombardment through the eons has pulverized the surface to a depth of several meters (yards ±) forming a powdery

blanket called the “regolith.” Because this material is representative of the host lunar endowment, it is a handily “pre-mined” source of most everything we will want to process on the Moon. Thanks to the natural production of the regolith, we won’t be “strip mining” the Moon.

1.01 One of the special handy features of the regolith is the presence of a considerable amount of pure “iron fines,” unoxidized (non-rusted) iron particles. Some years ago, **S**eattle **LU**nar **G**roup **S**tudies (**SLUGS**) determined that if you excavate a site (for the placement of a soil-shielded habitat), you will find in the material removed, enough pure iron particles from which to build the habitat to be placed in the excavation. This resource can be recovered for the price of a simple magnet. [MMM # 63 MAR ‘93 “Sintered Iron from Powder”].

1.02 Another special enhanced feature of the regolith is a considerable bounty of adsorbed solar wind gases [MMM # 23 MAR ‘89 pp 4-5 “Gas Scavenging”; MMM # 38 SEP ‘90 p 4 “Introductory Concepts of Regolith Primage”], thanks to eons of buffeting of the surface by the Solar Wind, blowing outward from the Sun’s surface. Involved are considerable amounts of hydrogen, nitrogen, carbon, garden variety helium, helium-3, neon, argon, and krypton, all recoverable through the application of a little concentrated solar heat.

1.03 Nor is that all. A third natural production within the regolith has been going on - again for billions of years. The natural production of glass spherules from the heat of micro-meteorite impacts.

Impact-derived Glass Spherules

SOURCE: **Planetary Science: A Lunar Perspective**. Stuart Ross Taylor. Lunar and Planetary Institute, Houston, and Research School of Earth Sciences, Australian National University, Canberra. © 1982

Glass: [Random House Dict.] [1] a hard, brittle, noncrystalline, more or less transparent substance, produced by fusion, usually consisting of mutually dissolved silica and silicates ... [2] or other ... natural substances with similar properties such as fused borax, obsidian, etc.

[Physically, glass is considered to be an extremely viscous liquid. Thus glass is markedly different from both crystal-line and ceramic materials. Transparency or translucency, while common, are not automatic nor essential characters.]

Impact-derived lunar glasses are commonly found as spheres, the rotational shapes assumed by splashed liquids, ranging widely in size. 100 microns [m] in diameter is typical (i.e. about a hundredth of a centimeter or 4 thousandths of an inch). [p. 128] Interestingly enough, this size/shape range are what we find on Earth for algal and bacterial one-celled micro-fossils, though the composition is totally different [p. 134].

The spherules are often flattened owing to the degree of plasticity at the time they “landed.” Broken pieces are common as are irregular masses coating larger particles in blotches. The spherules are themselves commonly “cratered” by even smaller micrometeorite impacts than those that led to their formation. Colors range from colorless through pale yellow, green, brown, orange to red, and black, and show a clear relation to refractive index and to chemical composition of the regolith material that became glassified by heat [p. 128].

Some glass spheres have inclusions of iron and nickel of foreign (meteorite) origin. Overall, the glasses are identical in composition to the host regolith material from which they were transformed [pp. 129-133].

These glass spherules are found in all lunar regolith soils, though the percentage by weight and volume varies.

Lunar Glass from other sources

Not all naturally produced glass on the Moon comes to us by way of meteorite impact heating. A primitive basaltic glass is represented in the Apollo 15 Hadley site “emerald green” samples [15425-6], comprising as much as 20% of the soil around Spur crater. And mare-forming basalt eruptions and volcanic fire fountains seem responsible for the orange glasses [74220, actually ranging in color from yellow to black] found on the rim of Shorty crater at the Apollo 17 Taurus-Littrow site [p. 128, pp. 297-300].

Industrial and other uses of glass spherules

Lunar glass spherules are **not** a starting point for optical glass and optical glass products like window panes and lenses, **nor** for the production either of high melting point fiberglass or low melting point glass matrix for the fabrication of “glass-glass composite” building component items [the MMM-proposed trade name for this GGC material is “Glax”]. For these things it will be necessary to start from

scratch with composition-controlled batches of ingredients. As this will depend on prior processing and production of the relatively pure ingredients needed, such building materials and construction items — as important as their local manufacture are to the goal of lunar settlement self-sufficiency — will be an achievement priority for a later phase of settlement industry.

Glass spherules, given their uncontrolled composition and color, still offer a number of useful product possibilities and applications that will give the early outpost/settlement-to-be an economically significant leg up. Here are some:

As is: (domestic)

√ abrasives and sandblasting material

√ water filtration

Remelted and blown (domestic and export)

√ early jewelry, art objects, giftware, souvenirs

√ early "issue" glassware, dishes

√ table/desk tops, lamp bases, etc.

Sorted for color (domestic and export)

√ early vitreous glazes

√ (jewelry and decorative ceramics)

Transformed by pressure and heat (domestic)

√ zeolites to add back into sifted powder-free regolith for use in agricultural soils

T**he list of capital equipment needed is modest:**

√ a way to extract from regolith (without confusion with similar size breccia and lithic particles)

√ size sort machine

√ color sort machine

√ furnace and blowers

As goals of lunar industry and export development, these product lines may seem minor. But together with the use of sintered iron products and regolith scavenged gases, they will work to jump start early and easy industrial diversification, reducing a small but significant part of the import burden, and giving the pioneers a well-deserved sense of achievement.

The Made-on-Luna logo above will have humble application at first, but thanks to prior "natural production" and serendipitously provident stockpiling of "not-quite-from-scratch materials," Lunar pioneers will be the beneficiaries of an industrial and economic handicap analogous, if not similar, to those we have enjoyed here on the cradle world. MMM

"Since new developments are the products of a creative mind, we must therefore stimulate and encourage that type of mind in every way possible."

"There is no short cut to achievement.
Life requires thorough preparation - veneer isn't worth anything. "

(Both quotes by) George Washington Carver

The Quest for Variety

SMALL MARKET SYNDROME

By Peter Kokh

Relevant Readings from Back Issues of MMM

MMM # 3 MAR '87, "Moon Mall"
MMM # 13 MAR '88, "Apparel"
MMM # 18, SEP '88, "Industrial M.U.S./c.l.e."
MMM # 22, FEB '89, "Hair"
MMM # 24 APR '91, "The Fourth 'R'"
MMM # 26 JUN '89, "Toy Chest"
MMM # 29 OCT '89 "The Role of Cottage Industries"
MMM # 32 FEB '90 pp 3-5 "Import/Export Equation"
MMM # 65 MAY '93, p 3 "The Substitution Game"; "Fast Road to Industrial M.U.S./c.l.e."; "Stowaway Imports"
MMM # 68 SEP '93, "Cornucopia Crops"
MMM # 77 JUL '94 "Cinderella Style"; "Furniture"
MMM # 85 MAY '95, p 1 "Safety Valve ..."

I'll never forget an experience as a fresh high school graduate of seventeen, browsing through the Hudson's Bay Company department store in Calgary, Alberta. The variety of goods seemed much greater than that at similar stores in my native Milwaukee. Here were to be found samplings of wears and wares from all the domains of the British Commonwealth, as diversified a market potluck of humanity as has ever existed.

On the Moon, shoppers are likely, at least in the early years, to have an experience just the opposite. Imported goods will be all but nonexistent and the exceptions will be prohibitively, obscenely expensive. The lunar domestic market will have to rely on its own resources primarily, other space-based markets eventually contributing their own offerings in trade.

"Small Market Syndrome" we might call it. Few people making few products to sell to few people. How do we avoid the expected consequence: little choice, little variety?

Prohibitive imports vs. small manufacturing base

The challenge for variety (unavailable either from terrestrially made imports or from the small local labor pool) will affect almost all categories of goods: building materials, vehicles and other conveyances, home furnishings, accessories and artifacts and giftware, clothing, appliances – you name it. Not only will it be harder to find items one really likes, but it will be harder to put a distinctive custom personality on one's home, even on one's wardrobe. Such a forecast presumes that the principal entry for variety is mass produced goods from a variety of sources. But there are at lest two other avenues by which satisfying variety can be provided under these constricting circumstances.

Potluck customizing

A machine producing a product can be shut down, retooled or given a setup change, and then come back up producing a somewhat different product. Until recently, the U.S. norm for setup changes across a broad range of industries was some 9 hours of downtime. The Japanese manage to cut the av-

erage setup downtime to mere minutes. There is no reason why a given piece of equipment cannot be tooled to produce a kaleidoscopic variety using a finite number of styling elements coming into play in diverse combinations. These might be programmed by computer, the changeout taking negligible time, with successive production runs of differently styled products (a radio chassis, a print pattern on a fabric, a handle design on a knife, etc.)

Or the diverse style elements can be preprogrammed to come into play in random combinations, one after the other (as lottery numbers are now stamped on the inside bottom of soda cans for example) Such "kaleidoscopic variegated product machines" could cheaply supply a significant range of individually distinctive items even for small markets. The variegation in each case would be confined to a set and recognizable "family character" range (given available styling elements, materials, colorants, etc.) within domestically supportable resource and feedstock limits without regard for the size of the domestic market. It may be possible to keep track by computer of the kaleidoscopic formula or setting for each individual piece so that patterns could effectively be saved to reproduce on request designs meeting special customer favor.

Finishing by individual artists and craftsmen

It is also possible to produce generic "unfinished" items, that can then be purchased by artists and craftsmen to finish and resell. Or an unfinished item can be purchased by the consumer and then given to an artist or craftsman of choice to be finished according to special request on commission.

While this is a slower, more labor-intensive method of introducing custom variety (than by way of the kaleidoscope machine), the results may (no guarantee) produce more artistically pleasing results, and the only way of producing non-random designs. Those who especially appreciate the hand-crafted and individually designed product may be willing to pay the extra price. But whence the artists and craftsmen?

Almost everyone will have a daytime job producing something essential for domestic or export markets, and for some time the bulk of art and craft may be executed in after hours spare time cottage industry style. Nonetheless, the demand may be so great that this need for variety in modern history's smallest market may well serve to usher in a "Golden Age" for artists and craftsmen quite without precedent.

We should also see the rise of an unprecedented number of amateur "do-it-yourself" artists and craftsmen principally finishing consumer goods for themselves, and perhaps as gifts for family and other loved ones. To serve this need, various unfinished product lines could be marketed with finishing kits, samples, suggestions, and useful tips. The enterprising factory might even have an area where customers can bring in their purchases to finish in factory supplied facilities using factory supplied materials and tools. This will be an especially economical and popular choice.

Domestic product lines it may become popular to customize are dishes (tableware), ceramic planters, furniture items, clothing items and ensembles, bed linens (in a factory furnished dying facility) and the like. Personalization and custom expression areas outside the home may include product lines that can be customized for entryways opening on pressurized streets, surface shield-roofs, and vehicles.

The subject of customizable "issue" furniture was discussed in MMM # 77 [reference above].

The multi-community lunar world

Once an initial lunar settlement is followed by a second, a third, and more of whatever size, their mutual isolation will inevitably lead to diverse paths being taken along all sorts of lines. Each having its own discrete mini-biosphere, the choices of climate, farm crop mix, and complimentary flora and fauna could be different. One of the results in addition to the obvious one of distinctive ambiances, might be different organic feedstocks to use in decorating clothing and artifacts.

But more basic than that will be differences in the suites of available inorganic materials. For the primary reason for establishment of additional outposts, at least early on, will be to exploit diversely endowed natural local environments. Thus a highland settlement will inevitably produce differently designed and styled goods from a mid-mare or coastal settlement to give one obvious example. While raw materials will certainly be traded among settlements, it would be natural for local artists and craftsmen to rely primarily on locally available materials. Trade between settlements then will be as brisk in value-added artist and craftsman-finished goods of locally distinctive flavor as it may be in raw materials.

Imports from other off planet communities

As strategically critical materials may well be cheaper to supply from other off-planet sources like the asteroids, Mars, and its moonlets, it will likely be a prime directive of any lunar settlement to support the opening of other off-planet outposts and markets in any way possible. Such a policy will also produce a stronger interdependent off-planet economy all the less vulnerable to interruptions of support from Earth. As these other markets develop, they too may be producing consumer goods which will be a cheaper source of variety than items from out of Earth's deeper gravity well.

Stowaway imports from Earth

While items imported from Earth either on speculation or by special order will be prohibitively expensive, there are other ways of getting Made-on-Earth wears and wares to the space frontier settlements.

(a) Clothing worn by arrivals, whether new settler recruits, official visitors, or tourists: such items can be traded duty free for Made-on-Luna wears, and then made available for specialty shop resale, or for playhouse (actors') wardrobes etc.

(b) Settler immigrants might be allowed a certain token heirloom weight allowance. Such items, of diverse individually chosen sort, will remain in settler homes for the most part, but eventually end up on the market or in museums.

(c) A subsidy for the import of art/craft tools (not materials) might be a good investment for all. (d) Earth-Moon ferries could conceivably be Earth-outfitted for the outbound journey, Moon-outfitted for the return, the Earth-made items finding their way onto the lunar market. MMM

For generations, Luna will remain a Frontier

By Peter Kokh

Relevant Readings from Back Issues of MMM

MMM # 3 MAR '87, "Moon Mall" MMM # 13 MAR '88, "Apparel" MMM # 15 MAY '88, "Rural Luna"
MMM # 18 SEP '88, "A strategy for following up lunar soil processing with industrial M.U.S./c.l.e."
MMM # 29 OCT '89, "Cottage Industries" MMM # 32 FEB '90, "Import-Export Equation"
MMM # 47 JUL '91, "Native Born" MMM # 55 MAY '92, pp 7-8, "Moon Roofs"; "Shantytown"
MMM # 56 JUN '92 "Harbor & Town" MMM # 57 JUL '92 pp 4-5 "Space Xity Biomass Ratios"
MMM # 65 MAY '93, "MUS/cle Substitutions" MMM # 83 MAR '95, p 5 "Tarns"
MMM # 84 APR '95, p 5 "Ghost Towns and Ruins"

"Praise the darkness, and creation unfinished!"

- Ursula K. LeGuin in "The Left Hand of Darkness"

In the Moon, we have a lifeless, barren world that would seem to be anything but friendly. We cannot deal with it at all as "naked apes," but only through the mated interfaces of technology and biospherics. Far more than other "alien shores" we've come across before, on this globe of unrelieved horizons of rock and rock powder against an unfiltered sky of cosmic hazards, we have little of past precedent to go on - little except the spirit of our pioneering past.

The Moon presents itself as a frontier in a much more pervasive and deep-challenging sense than has any previously unexplored and uninhabited niche on Earth. True, terrestrial frontiers have confronted us with challenges we don't have to worry about on the Moon: wild animals; strange diseases; the elements of fire, wind, water, and ice; and unfriendly natives.

Our acculturation to the Moon will have to be more far-reaching and all-encompassing than any humans have had to make to date. This will be necessary if we are someday to sit back and realize that through seemingly endless struggles with one problem after another, through battles lost and won, with ourselves as much as with our adopted world, we've somehow come, amazingly, to feel enough "at home" to experience real contentment, to let go of standby plans to return to Earth if in the end the rows of hurdles are just too much.

Frontier Interfacing 1.01

It would seem to some that the technical challenges to extended human presence on the Moon are either solved, on the way to being solved, or present only modest difficulties. In fact, most of the more flippantly offered solutions exist only on paper, or have been tried only in a laboratory without review by the engineers who would have to scale them up, and certainly not in any integrated systems approach. The early challenges include low-leakage pressurization integrity, thermal management, dust control, and overnighting power supply.

Beyond that, we must quickly progress beyond imported habitat volumes (rigid, inflatable, and hybrids) to (a) demonstration of building materials easily, efficiently, and reliably processed from lunar materials, (b) demonstration of fabrication of modules and modular elements made from them, and (c) demonstration of construction techniques based on them. Nor will this ever be a "been there, done that" step. Lunar pioneers, deprived of the enormous repertoire of manufacturing stuffs and building materials nowadays available on Earth, will be challenged into the indefinite future to come up with new solutions, better fit for newer applications. It will not be enough to demonstrate crude sintered iron technology or crude glass composites (Glax - suggested generic trade name for the whole family of likely formulations) technology. Lunans will have to aggressively seek to add to their stable of metal alloys, ever more specialized and higher performing glass and glass composites, ceramics, lunar concrete, sulfur composites, and other inorganic possibilities. All of these curiosities will not come on line together, or quickly. And until we've learned the whole suite of "lunar tricks," for all our achievements, we'll still be on a frotier.

"Nuke" solutions notwithstanding, there will always be more power available during dayspan (when "solar" can be tapped) than during nightspan, baring the achievement of some circumlunar superconducting power grid in which dayspan solar cogeneration additions anywhere can feed nightspan power demands anywhere else without appreciable losses. This means that the dayspan-nightspan polarization of processing, manufacturing, and labor duties that we have forecast (energy-intensive and labor-light vs. energy-light and labor-intensive) is likely to characterize lunar living rhythms for a long time. Even after good solutions to the overnighting problem have been found, relics of this sunthly task-switching routine are likely to endure, having become endeared to the population.

Settlement architecture and general plans are likewise not soon likely to be mature. Regolith-buried modular towns are the early likely favorite, along with modular outposts within the protective cavernous "lee space" of handy lavatubes. But beyond that the vision lures of more "Earth-normal" type of habitat architectures within atmosphere containing mega-structures: domed craters and crater chains ("catennae)", vaulted rille valleys [the LRS "Prinzton Settlement Study," detailed in the MMM series "Ventures of the Rille People" in MMM #s 26-33 JUN '89 - MAR '90], pressurized lavatubes, and similar farther-future dreams. It is dreams that provide any frontier with its fountain of youth, and with the vision of how it was, how it is on Earth taunting rugged lunar pioneers, they are not likely to ever be satisfied until they have been able to token-reproduce as much of Old Earth on the Moon as possible.

How extensive can lunar settlement become? Those of little imagination would go to their graves content and satisfied if we establish a vintage Little America type outpost with a handful of people. But the Moon is a very empty world, and only the size of the interdependent interplanetary economy can limit the growth of a lunar human population. Even if we limit our settlement areas, including biological natural parks and parkways, to the available "square miles of prime turf" (the definition will change as our capacities change: "ideal size" craters, crater chains, lavatubes, and rilles, etc.) - we will find enough of that to comfortable house and feed and recreate a population of some millions, only a fraction of whom need to be engaged in production for export. So from outpost to an appreciable off-world population, a progression that will take generations, the Moon will remain a "frontier."

On Earth, pioneering a new territory has always been relatively easy. On the Moon we will have to cope with an across-the-board dearth of all the "in situ" assists and handicaps we have enjoyed in the past. We will find no trees, no wood, no bamboo, rattan or reeds or bark. There will be no food for the finding: no fish to catch, no game to hunt, no berries or nuts or seeds to gather. There will be no rich ores of iron, copper, or other metals to prospect. In addition to the lack of wood, there will be clay, no sod, no easy carve stone to use as building materials for shelter, not that we could seal them against the vacuum and cosmic elements if they were on hand. Nor, to make ourselves at home, will we find ready or almost ready to use art and craft materials.

We'll be learning what to make and how to make it, over and over again, medium after medium, for a long time. In the process we will cope better and better with the exclusions and substitutions and compensations - the lunar facts of life.

We'll have to adjust to material excesses as well as material insufficiencies. Regolith, regolith everywhere, with its intrusive and all-befouling dust - a challenge to housekeeping, to machinery with moving parts, to health. For most, that first fresh-off-the-lander impression of "magnificent desolation" will soon be replaced with an innocence-lost lasting impression of scenic monotony and boredom. Lucky the few for whom the variability of the lunar topography will never cease to amaze, with every new moonscape around the bend or over the rim! But for all, on the Moon we will be greeted only by rock, stone and dust: geology unrelieved by life with its verdant vegetation in so many forms, along with expanses of water: streams, lakes and seas. It is this combo of the awesome and the beautiful that has made our home world the lonely jewel it is, for as far off into the starry reaches as we have yet to thoroughly probe.

And then there are the black skies - as black by dayspan as by nightspan, unrelieved by alternating equal time periods of horizon to horizon sky-blue, variably pocked with restless white to gray clouds. Again, lucky the few who will never cease to be thrilled and soul-sucked by the clusters and clouds of stars - for these, when all is said and done, remain "the" frontier of human destiny.

Frontier Biospherics 1.01

If "gray engineering" has technical problems yet to be addressed, "green engineering" as it will be required on the off-planet frontier is in its earliest fetal stages. Most, amazingly not all, do appreciate that we cannot return to the Moon "to stay" without being prepared to aggressively phase in a mini- but functionally integral "biosphere" to reencradle ourselves on worlds without atmosphere, hydrosphere, and native flora and fauna. We may have long taken it for granted, but that does not alter the fact that we are quintessentially a symbiotic species. We must take our symbiotic partner with us as we move out into space. That partner is Earth-life in general, call it Gaia if you are not too hung up on the speculative excesses of the Margulis-Lovelock feedback theories. Sure we expect to be able to engineer an artificial symbiote: chemically regenerated air and water reserves, and foodstuffs à la Solyent Green. And need this approach we will, for cramped conditions on space stations and long-voyage spacecraft. After all, we have a long tradition of substitution of less than ideal life-support means aboard submarines, ships in general, and Arctic and Antarctic research stations. But long term, such measures can only support a caricature of human settlement.

Normalcy, such as a general population will find tolerable, will require "nature" in recognizable familiar terms to be involved. At first this involvement may be token, as with salad stuff cubicle farms, and CO2 scrubbing algal vats etc. But without the sure prospect and unquestionable commitment to a schedule of progress in the general direction of a self-maintaining diversified and balanced biosphere regenerating clean air and water, as well as producing ample food, fiber, and feedstocks of various utilities, frontier settlement will not be psychologically tolerable or self-maintaining in any sense.

Think of the ratio of water tonnage to biomass tonnage on Earth, and then of the ratio of biomass tonnage to the gross weight of the human population on Earth. Obviously, we have a tremendously long road to travel on the Moon or in other off-planet biosphere sites if these terrestrial ratios are the standards at which we ought to aim. Even with such high ratios, we are now seriously straining the recuperative capacities of our environment. How could we pretend to dream of not poisoning ourselves in very short order if, in off-planet mini-biosphere-wannabes the ratios of water:biomass: humans are only ridiculous tokens? Our mini-biospheres must be very extensive: not landscaped cities, but farming villages with farms. It is vegetation that must play host to man, not man to vegetation à la houseplants! Until this is the case, and it is a direction to move in, not something we can achieve at the outset, lunar settlements will still be "the frontier."

Diversity of agricultural crops and complementary wild plant species, and a certain amount of post-human wild life as well (such as we find in our own urban and suburban and farming areas) will also be needed to provide a real biological flywheel as well as increasingly good mental health.

Frontier Economic Stratagems 1.01

Those whose bottom line dream is of a settlement invulnerable to the political and economic whims upon which continued lifeline support from Earth must always rest, face a long uphill struggle. In such a campaign nothing can be overlooked, certainly not the dollars, but neither the pennies. In addition to the obligatory money-earners like Lunox and a few other export items that have occurred to nearly everyone, there are innumerable less glamorous potential export commodities. (Anything Lunans can make for themselves at less expense than they can upport an equivalent out of Earth's deep gravity well, they can also sell to other space markets at a similar disadvantage: LEO and GEO lab-stations, factories, resorts; L4 and L5 space oases; and other off-planet pockets of human presence.) As anyone who has ever managed a budget knows, the nickels and dimes do add up, inexorably, often to sums that literally dwarf more attention-getting dollar expenditures.

Thus it is absolutely imperative that the domestic lunar economy not be neglected in favor of concentration on production of obvious exports. That would be self-defeating.

At the same time, it is clear from the limited suite of economically producible lunar elements as well as the limited manpower pool, that not everything we might want to have on the Moon can in any foreseeable future be produced there. These facts of lunar life suggest the M.U.S./c.l.e. stratagem in which Lunans concentrate on self-manufacturing the more Massive, Unitary, and Simple components of various items they need, and be content with importing ready to assemble works cartridges containing any complex, lightweight, and/or electronic elements required. An Institute of Lunar-Appropriate Industrial Design, perhaps on Earth, could design products from scratch for just such a collaboration. Lunar products, all exportable, could include habitat and ship and vehicle hulls and body components, tankage, furniture, appliance casings, etc. In aggregate, the total import burden could be decimated.

The "yoke sac" stratagem is another "piece of the puzzle." Lunans must move to quickly extricate themselves from realistically fickle umbilical dependence on Earthside policy-reviewers. Instead of supplies received "just on time," the current newly embraced conventional wisdom, settlement fathers need to over-import any stra-

tegic commodities without which outpost failure is certain, swift, and without recovery. If economically recoverable water-ice reserves are not confirmed at the lunar poles, hydrogen will certainly be at the top of that list, along with sister volatiles carbon and nitrogen. A tank farm with a 2-5 year supply (based on growth assumptions) of methane and ammonia ought to do the trick.

Added reserves that need to be built up are copper and other industrially important metals, scarce or not yet economically producible on the Moon, including needed alloy ingredients; nutrient additions for regolith-soil-based farm production; pharmaceuticals or their feedstocks. We'll also need well-stocked tool cribs and parts stores. The settlers need reserves to buy time in which to open up alternative sources if the squeeze is put on, deliberately or as an unfortunate side-effect of some unrelated policy development on Earth. Strategic planners must seek to open alternative off-planet sources of critical materials in seeking to build an independent capacity to self-replenish them. This is the frontier.

Opening the Solar System in general is part and parcel of securing the future of the lunar settlement. Other off-planet pockets of humanity will make more dependable trading partners. Early daughter frontiers may include asteroid mining operations, a Mars colony and processing and manufacturing facilities on its moonlets, Phobos and Deimos.

But they will also include the genteel "**suborbs**" - more sophisticated and Earth-reminiscent space oases settlements - or so the expectation goes. In truth, these artificial "outside-in" worldlets will be "lunar frontiers" in disguise, where Made-on-Luna items and lunar raw materials will be less expensive than more desirable, more sophisticated equivalents made on Earth.

Attracting Immigrants will also be vital to maintain and grow the settlement in a viable and sustainable fashion. To do this, the powers that be must "sell" the frontier, making its obvious and undeniable hardships come across as "more than worth it," however counter-intuitively, in light of the rewards. If the "sell' is done right, it will attract the right people, the ones who will be able to contribute to the building of the frontier, and who will find themselves amply rewarded by the intangible satisfactions that will come, however haltingly, from being able to make a real difference at ground floor level.

Immigration - selling the frontier

Frontier Adjustment 1.01

Many are the psychological adjustments that will be needed to be made, some of them over and over again, by those who have taken the plunge and made an honest commitment of the rest of their lives to their new adopted home world. They will have chosen to forsake the world of their birth with all its real attractions and advantages.

Consumer types who crave the latest and finest need not apply. Early settlement "issue" wears and wares will be crude and esthetically uninteresting, however serviceable. Local arts and crafts will develop slowly, and with them, the prospect of nicer things. The small market in tandem with other off-planet markets, will mean markedly fewer choices.

Those needing lots of elbow room will also have a hard time of it. Even with inflatable and hybrid rigid-inflatable prefab shelter imports, per person private and common spaces alike will be at a premium until shelter can be built routinely and generously with local materials we've learned to process and fabricate and erect on the Moon.

Occupational options will at first be limited, but expand in diversity exponentially as the population grows. There will be those with the psychological "right stuff" who will need at least temporary occupational reassignment.

A very real sacrifice, one most do not expect, is the enormous physiological obstacle that will build up over years in the way of ever returning to Earth, a place where one would suddenly, not gradually, weigh 6 times (not 1/6th) more than one had become accustomed to bearing. Earth, and its beauty and meccas of many kinds, will inexorably become a destination out of reach except for the physically most determined.

Risk acceptance will be a frontier trait that affects much more than the prospects of ever reneging on one's settler commitment. Lunans will live far, in gravity well terms, from Earth's encyclopedic problem-fixing resources. Some equipment may rest unused, waiting unaffordable repairs or parts. "Medical Triage," however, will be a more powerful concern for the less than supremely dedicated. Despite possible development of time-delay-scourged labaroscopic surgical teleoperation procedures, many less common medical crises, manageable on Earth, may mean certain death on the frontier.

Frontier Prospects

It is characteristic of any frontier for there to be too many jobs needing done for the too few people available to do them. The frontier puts a strong premium on multitalented individuals. Everyone has the opportunity to be useful, even the young, the handicapped, and the elderly. And these ground-floor openings will give all a chance to make meaningful, satisfying differences that will be worth all the hardships.

The LeGuin quote at the top sums it all up. The darkness of hardships and sacrifice are undeniable. But nowhere is Creation more Unfinished than on the frontier. And it is "that opportunity" for us to help finish creation which makes being human so much more than a cosmic joke. MMM

MMM #102 - FEBRUARY 1997

The Luna City Museum

Visitors' Guide - 2097

[This article is included to provide context]

Musings by Peter Kokh from a visit to the Milwaukee Public Museum, while on Jury Duty lunch break 9/13/'96

The Function of Museums

For many people, museums are dusty, musty old places filled with assorted collections of useless items with no relevance for daily life. Their loss.

Museums are meant to be, and are indeed for those in on the secret, well springs of inspiration in dealing with the world of today and everyday.

People who visit them, even "once in a blue moon", can scarcely avoid leaving their halls without a sense of being enriched with a greater insight into the present as well as a heightened appreciation for the past, and even - here is the punch line - with a more well-founded cautious optimism about the future.

The Natural History exhibits help correct our sense of place in the cosmic scheme of things and events, infecting us with deeper respect for our birth planet and its features, and with a greater sense of connection with our plant and animal kingdom fellow travelers in this biosphere of tightly interwoven interdependencies. We see illustrated our calling to serve as stewards for what we have inherited.

The cultural exhibits give us new awareness of the contributions to the material and artistic and scientific wealth we all enjoy today - contributions made by those who have gone before. Exhibits of foreign and of primitive cultures teach us that our solutions are not the only ones, and that resourceful coming to grips with local environments and assets is a universal manifestation of the human spirit, its problem solving powers, and its hardship and disaster meeting resilience.

The Function of a Museum on the Moon

What might a Future Lunar Pioneer Museum display? Two classes of deposit materials are already on hand and need not be shipped to the Moon. Soil ("regolith", the meteorite-pulverized blanket layer that covers the lunar surface) and rock and meteorite samples to be collected from the various representative types of lunar terrain. These can be exhibited in diorama contexts to acquaint museum visitors with the makeup of the lunar landscape both locally and in other, perhaps quite different regions. Other dioramas will bring to light what it is like within the eternally dark lunar lavatubes. The Moon's geological Past, Present, and Future will be unfolded.

Second, there is the now 2.5-3 decades old relics of the half dozen human scouting expeditions of the Apollo Program as well as relics of robotic missions from before, and since.— the museum "hope chest" some shallow-thinking people call "trash".

The purpose of a museum is to visually remember and appreciate the Past in the Present through samples and representations displayed in context. In this manner the roots of local culture and civilization are illuminated, and those who come to study these displays gain a cross fertilization of ideas, inspiration in current challenges to resource-fullness, and confidence that we can always find ways to adapt to current conditions as have all past populations. Visitors come to appreciate the ever surprising adaptability of life and man, the viability and poly-expressiveness of life. Collections and collectibles illustrate the enormous variety of nature as of human possibilities. We learn about the relationships of living ecosystems (natural, and post-human alike; of Earth's planetary Biosphere, and in working (or struggling) off-planet mini-biospheres. The dependence of human life on nature, both

geologically and biologically is brought home. Relationships, progress, evolution, revolution, etc. - the never-ending epic of nature, life, and man are

The Luna City Museum of 2097 should be no different. Starting with the the two classes of natural and human artifacts already on hand,

The museum's job will be to successfully chronicle the unfolding of the human frontier.

The visitor of 2097, be he or she a visitor from Earth or a native born 4th generation Lunan, will learn how those who have gone before have built up the lunar civilization of the day, bit by bit, resourcefully and without discouragement through an endless list of challenges, hardships and sacrifices, setbacks and temporary tragedies.

Early products of the frontier settlements and there slow steady diversification and growing sophistication and level of attainment will be on display. Arts and crafts, apparel, games, furniture, furnishings, homes, meals, shops and shop-ping, occupations, amusements, hair fashions, festival trappings, hobbies, schools, musical instruments, street scenes, sports, frontier lifestyles and hardships - these will all be on display in variety, joining displays of the products of heavier and more mundane pioneer lunar industries.

The special contributions of immigrants from various terrestrial nations and ethnic backgrounds will also be displayed, their diversity being most strong in arts and crafts contributions. One "wing" of the museum might be occupied by the "Streets of Old Luna City" exhibit. In 2097, native born Lunans may have come to take their culture and now successful and thriving civilization for granted. It will be the museum that will get across to them, how precarious and problematic life was for their ancestors. Humility, inspiration, encouragement, and determination to do the past and one's forbearers proud should be among the fruits of the visit. For museum visitors from Earth, any feelings of superiority and condescension towards the unsophisticated and boorish Lunan rustics should be dissolved. They will be left to wonder if they could have survived the challenges clearly bested by the lunar frontier folk.

Periods of Frontier Development

Visitors will learn clearly the relationship of various intermediate periods of lunar history, and of the arts, crafts, fashions, customs, and products they produced. They will learn of the first crude faltering lunar outpost and settlement biospheres, and come to appreciate what it takes to make them and the utility systems that work with them function to guarantee continued Lunan existence.

Showcasing unsuspected diversity

"When you've seen one Lunan town, you'll have seen them all!" Anyone who says something like this will say more about his or her own shallow lack of perception than about the Lunar frontier. The discrete and all but mutually quarantined lunar settlement biospheres will sport considerable diversity, as will the architectural solutions employed within, the local "middoor" climates, and local arts and crafts traditions. Sure there will be telltale common threads. But vive la difference! To boot, the lunar frontier environment will have fostered a great number of social and cultural experiments and a number of "intentional communities" will have been launched. Of these many way be still-born, many to falter sooner or later, some to survive only by going "mainstream", but some few making their dream a reality, if not quite in the shape and form envisioned by their inspired founders. All this will be material for the Luna City Museum curators.

Frontier flora and fauna vs. that of Earth

Illustrated as well will be the life cycles of plants and animals successfully transplanted into and thriving in Lunan mini-biospheres, no two of these quite alike. But it won't be all about Luna and the Lunar Frontier Republic.

The Luna City Museum will want to gradually build up its collections that will paint an ever fuller picture of what the settlers have left behind. From nature their will be sweeping diorama vistas of terrestrial habitats: seashores and river valleys and deserts and mountains and waterfalls and forests and prairies and jungles and swamps and tundras; plant and animal collections in great diversity, each in ecosystem context. Given the cost of shipment from Earth of physical display materials, audiovisual virtual reality displays will probably predominate.

Showcasing the Lunar Economy, Arts, Culture

But Lunans will also learn of occupations and hobbies, and sports, and recreations common on Earth which have been difficult or impossible to translate with justice in the settings of their new adopted home world. They will catch an idea of what it is like to sail, to soar, to ski, to run under open skies, to picnic under pillow-shaped clouds playing tag with the Sun, of what it must be like to hunt and fish and gather in the wild. They will learn of the quite different suite of natural perils: volcanoes and

earthquakes and hurricanes and tornadoes and forest fires and mud slides and blizzards and floods and tidal waves. For Lunans must be shown not only the roots of who they are, to appreciate more fully who they have become.

And they will learn of the somewhat similar and somewhat different challenges and achievements of other Earth-foresakers, those who have chosen Mars, or the asteroids or empty space for their world setting. they must learn of what they have left behind

The Luna City Museum of 2097 is likely to have earned its billing as a pillar institution of Lunan settlement culture and civilization. MMM

MMM #109 - OCTOBER 1997

LUNA CITY STREETS

By Peter Kokh

[Only those parts of the original article which provide "context" for lunar Arts & Crafts are reprinted below.]

Foreword

[NOTE: In MMM #52 FEB '92 p. 2 "Xities" we introduced the term "Xity" (to be pronounced KSIH ty, not EX ity). "Beyond-the-cradle off-Earth settlements ("Xities") will be fundamentally different from the familiar Biosphere-"I"-coddled "cities" that have arisen over the ages to thrive within the given generous maternal biosphere that we have largely taken for granted. Elsewhere within our solar system, each xity must provide, nourish, and maintain a biosphere of its own . Together with their mutual physical isolation by surrounding vacuum or unbreathable planetary atmospheres, this central fact has radical ramifications that must immediately transform space frontier xities into something cities never were."

In the same issue, the following article "XitiTech", pp. 3-5, we investigated a gamut of essential xity functions, some familiar but strongly redefined, others new and without precedent, and their demands upon the structure of xity bureaucracies, government, and politics.]

The "Streets" of Luna City

We might define a street as an engineered passageway that connects buildings and other places where people, live, work, shop, play, and otherwise congregate. The earliest improvements in the construction of village and urban streets include paving and guttering.

In temperate climates and seasons, the structure of a street and access to it is simple. In more extreme climates and seasons, access to the street has encouraged the construction of buffering foyers, porches and awnings, and pedestrian arcades as well as the donning of gear more or less adequate to the inclemencies to be braved.

In more modern times, we have seen the emergence of climate controlled pedestrian malls everywhere where heat, cold, rain or snow might interfere with profit-generating shopping activities. And we've seen as well the downtown sky-walks and underground galleries facilitating the busy bustle of vibrant snow belt downtowns, for example, those of Montreal and Minneapolis. Yet, despite such developments, it is still far more common for pedestrian and vehicular traffic to share rights of way.

In the thirties and forties, it was the common shared vision of the future that grade separations would universally replace in grade intersections. The expense of such a widespread infrastructure rebuilding, however, has limited this "stop-free" feature to all new "freeways" and "expressways" and scattered ultra-busy urban arterial intersections.

On streets of mixed use, the tendency has always been to maximize the amount of activity they enable. They are landscaped for maximum ambiance and attractiveness, and lined with shops, eateries, service establishments and other amenities meant to encourage pedestrian and vehicle stop-ins.

What might the streets of a future Luna City be like in the early era of settlement?

On the Moon we have inarguably extreme climate at all times: radiation-washed, micrometeorite-splashed hard vacuum with extreme though superficial temperature swings. A more benign “lee vacuum” is available at the price of a ramada* or canopy over the trafficway. But for urban in-town purposes, all purpose pressurized climate-controlled shirt sleeve accessible pedestrian and traffic tubes will be as vital as the pressurized, climate-controlled shirt sleeve accessible habitats, labs, factories, shops, offices, etc. that they link in one inter-continuous mini-biospheric maze. In the course of everyday life, the urbane Lunan will don a spacesuit only during infrequent but seriously conducted “decompression drills”. Even travel “abroad” to other settlements or outposts will be by hard-cocked vehicles, our airport jetways offering a very primitive foretaste.

Size and Scale

The humble ancestor of the lunar settlement street will be the outpost hallway as it first becomes suddenly transformed by the merchandising of dawn era made-on-Luna artifacts (wares, wears, or both). As the outpost is superseded or absorbed into a conscious settlement effort fueled by the availability of locally processed building materials and architectural components, such cramped passageways will be followed by much more spacious corridors handling both people and vehicles.

If we must build these long interconnecting cylinders to carry the everyday commercial and social intercourse of the lunar city, then surely it makes sense to build them on a generous scale, with ample radius to allow not only pedestrian and vehicular traffic, but serious agriculturally productive landscaping. This more directly interconnected city gridway-plex would then contain the lion’s share of the city’s shared biosphere and of its biomass-run climatic and regeneration flywheel.

[MMM # 51 DEC 91, p.p. 3-4 “Everfresh”]

[MMM # 57 JUL 92, p. 6 “Space Xity Biomass Ratios”]

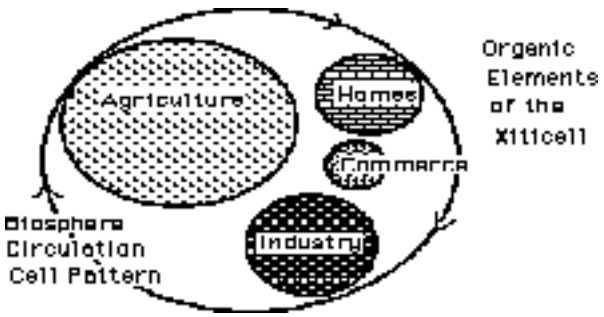
[MMM # 64 APR 93, p. 9 “Towards Biosphere Mark III”]

[MMM # 96 JUN 96, p. 5 “A Green Security Blanket”]

As a reality check, however, it is important to add that such thoroughfare cylinder (sections) will not exceed in girth that maximum diameter which the settlement is currently able to fabricate. So the earliest settlement streets may be relatively more narrow, even as were those early streets of colonial Boston and Philadelphia that still survive. And perhaps that is as well, for the larger the volume to be pressurized, the more inert nitrogen the pioneers will need to import at high cost to the young settlement. The ideal is clear, however, and will serve as a driver of fabrication capacity.

Once more generously radiuses cylinder sections can be built, these may be reserved for neighborhood-connecting cross-town arterials, and for commercial, industrial, and agricultural frontage roads. The narrower variety may continue to be produced for use as quieter, cozier traffic-restricted residential lanes. On the other hand, large enough cylinders could contain housing on their side terraces rather than just provide access to separately built modular housing, as illustrated below:

Whatever their individual dimensions, the town street grid would present minimally clogging obstructions to an effective air circulation system. This could be set up to flow in neighborhood cellular loops* starting with farms, flowing through residential areas, past commercial areas, through industrial zones and back into the farms in self-cleansing loops similar to the human heart-artery-vein-liver-lung loop. In contrast the aggregate of individual and conjoined homes, town homes, and apartments, of shops, offices, factories, schools etc. that we more commonly think of as “the city” will in large measure be interconnected only indirectly, via the street-plex.



BASIC ELEMENTS OF THE XITY FOUND IN XITICELLS

A generous radius would allow pedestrian and mezzanines lined with alcove shops and cafés, tiered above general trafficways and transitways, still allowing relatively uninterrupted green space on the floor and terraces. To make that work, relatively continuous solar access strips will be built-in features of the ceiling, if not replaced by artificial but more efficient gro-lighting. Nightspan lighting can make use of the solar access system (the actual lamps, and their heat, situated out-vac on the surface) or via artificial task and area spot-lighting.

The ceiling vaults of these multipurpose galleries might be sprayed a soft matte-white(-wash) finish of CaO (lime) or TiO2 titanium dioxide, whichever is the more cheaply producible from local regolith soils. Such an eye-relieving vault or "firmament" might be given an Earth-like sky-blue cast by backlighting it through blue glass panes or lenses, whatever the actual light source, or by carefully diffused blue neon cove lighting, using solar wind gases. Attention paid to this artificial 'sky' will pay off.

Free side wall areas can be undecorated, self-decorated playing to the character of the locally made building material out of which the street cylinder is made, decorated with glass and/or ceramic mosaic creations, billboarded (point-of-sale signage especially) or covered with commissioned murals or code-governed graffiti or popular street art of various forms.

As we've pointed out elsewhere, "somewhat clean" reserve water on route to further processing could be channeled through the agricultural or landscape terraces via open canals and/or trout-streams and thus do double duty, creating ambiance, allowing canoeing and row-boating, fish-watching, even trout-fishing. Here and there sidewater lagoons can serve as swimming ponds and water lily gardens, even a lagoon for a city mascot pair of flamingos. Here and there, cascades and locks and waterfalls and arched pedestrian bridges can be worked into the scheme. Periodic dehumidifiers (humidity, not dryness, is expected to be the bane of man-made biospheres) can feed waterfalls and drinking fountains, draining into the fresh water supply lines. [MMM # 67 JUL 93, p. 6 "Reservoirs"]

The "Middoors"

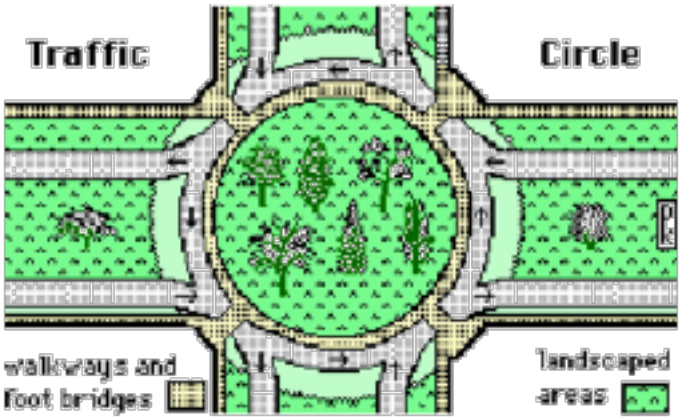
The beachhead science outpost will be simply a pressurized indoors up against the outlocks vacuum, the out-vac. Whenever it makes its appearance, in such a government outpost or in an early company mining town, the construction of the first spacious atrium solarium garden will introduce a new kind of space - a space external to individual quarters, lab modules, and other work- and function-dedicated pressurized places, yet still keeping out the life-quenching vacuum beyond the airlocks and the docking ports. What we have called the "middoors" will be born.

From this humble beginning, airy, spacious, verdant middoor spaces will grow to the point that they may eventually contain the greater part of the settlement's atmosphere and biomass. And with it, the hoped for "biospheric flywheel" will become much more of a reality.

It is within such spaces that longer, wider sight lines will appear, offering postcard views and vistas, to dull the edge of early day claustrophobia. The settlement will begin to take on the trappings of a little "world", a continuum of varying horizons. The effects on settler morale will be considerable.

"Indoor" spaces will be the more tightly climate controlled, allowed to vary only slightly from comfortable "room temperature" and humidity levels. In contrast, the middoors may be designed to swing freely, say from a late pre-sunset dayspan temperature that is tolerably warm and humid, to a late predawn nightspan temperature just enough above freezing not to harm the various plant-forms within. "Sunthly" "weather" patterns will add welcome variety and spice to day-in, day-out life.

That foremost conversation-making unpredictability of terrestrial weather, however, may be hard to program in. If temperate food plants are desired, perhaps an annual hard frost might be arranged one nightspan a year, as part of a partial cleansing freezing out of mounting atmospheric pollutants and impurities. It's a thought. And depending on ceiling heights of the street vaults, any gradual increase of humidity levels beyond a certain point might trigger mist-making condensations, say sometime after local sunset. At any rate, such middoor "weather changes" will help keep the populace healthfully invigorated, as well as supplied something innocuous to complain about. A fringe benefit will be the generation of a whole new cottage industry to create fashionable "outerwear."



A tri-level grade separation (2 free through-flow separated levels, a 3rd signal controlled turn level, alternately allowing two sets of turns as below) would be desirable where traffic volume is greater.

Sound Baffling: If we don't want the settlement and its middoors street-plex to be intolerably demoralizing over the long haul, architects and engineers will have to give full attention to sound baffling - something that is of much less concern in our terrestrial open-sky cities. The needed materials and construction methods should pose no problem. Whether bound -baffling features should be built into intersection nodes is a decision that will be made opportunistically, depending on overall design and other special features. Certainly, vegetation and trees would help.

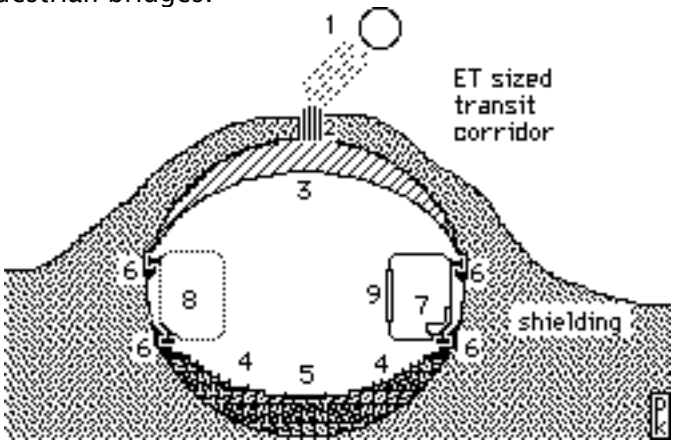
Expected use patterns: hosting town center institutions, offices, commercial shopping, entrepreneurs, cottage industry and arts and crafts markets and fairs, food court and rendezvous plazas, hosting festivals and parades, etc.

Signage, Lighting, and Individual Ambiance can be given architectural roots, and left to user embellishment. No busy settlement intersection need look like any other (e.g. the strikingly different, each stunningly beautiful stations on the Moscow Metro Circle Line).

To serve pedestrian traffic between parallel or neighboring streets in areas where intersecting streets are far apart, "shortcut" pedestrian "cunnicular" tubes might be built. These will be small in radius, at best with a shallow side terrace for hanging plants, flowers, bonsai forest strips etc.

Public Transit Options

In the same environment, public transit vehicles can also be open-air, starting with simple railing-sided flatbed street rail cars with benches, operating automatically much as modern operator-free elevators. Trackless trolleys are feasible. Battery operated coaches will be more expensive to operate. In the light gravity of the Moon, side-rail suspended cars and vault-susupended monorail cars should be very feasible and popular. Station stops could be just before or just after intersection nodes, or handy to mid-block pedestrian bridges.



KEY: (1) Sun, (2) fiber optic bundle sun pipe, (3) sky-blue sunlight diffuser (same air pressure both sides), (4) terraced plant beds, (5) gardener's path, (6) wall-mounted rail suspension system, (7,8) bench seat transit car, (9) door.

Special Uses

Commercial concentrations can either grow up around favorably designed or well-placed intersections, or alongside individual street cylinders themselves. “Nucleus” intersections can be built at planned intervals, each to develop their own individual mix and ambiance as neighboring enterprises and cottage industries and neighborhood associations make use of them. One such may in time emerge as hub of “the downtown” but that can be left to the free unfolding of city life, and need not necessarily be preplanned.

Some streets may be specially designed to handle ethnic, music, and art festivals. Others can be laid out with parades in mind. And some should be intended to serve as park strips for retreat and relaxation and fuller enjoyment of urban greenery, maybe even token urban wildlife [see below].

Custom Frontages

Pressurized residential lanes, commercial avenues, and industrial roads will each offer their respective frontage-holders the opportunity to landscape, remodel, and redecorate the entrance vicinities to their individual residences or establishments. It is this street-connected building interface which is the latter’s public face. The out-vac exterior (elevations), in contrast, will in most instances be seen by very few, and consequently invite little image-broadcasting attention.

Each pressurized cylinder designed to host a street scape will come (be built) pre-outfitted with a particular placement of doorways and doorway types, — dockage, if you will, for adjoining pressurized structures. The various side entrance formats will establish a fairly rigorous zoning regime: residential, commercial, industrial, agricultural, etc.

For proprietors and homeowners, flower and plant beds, whether merely decorative or useful (fruit, vegetable, herb & spice, dyestuff, fibrous, pharmaceutical, etc.) options are quite varied and lend themselves to personalization both in choice and arrangement. Complementing them, doorways and façades can be variously done in cement, ceramic tile, brick, stained glass, pebbledash, metal, etc. Holiday and festival decoration can be made of creations from harvested biomass.

Sidewall section of a residential street,
suggesting how homeowners might customize their entrance façades.

Pools of dayspan sunshine may mark every entrance to off street property, provided for in advance by the positioning of solar access in the cylinder vault. This external “atrium” can be contiguous to,or separated from,a larger solar garden atrium central to the home, etc. There are lots of options, and a healthy variety will be the result.

Each entry becomes the canvas for a distinctive statement. The street frontage serves as the interface through which individual-private and shared-public worlds meet. The entrance, whether to a residence or an establishment, is a special fixed place that sets the mood and tone for all who enter. It says “I’m unique and proud of it.”

There are, of course, also those several mobile interfaces with the world which accompany us on our excursions into it and through which we also state our identities: hairdo, cosmetics, jewelry, clothing, and personal vehicles. To serve all these markets for personalization, as well as in-home custom decor and appointments, a healthy variety of cottage industries will rise and thrive.

What about homeowners and proprietors who chose to leave their streetside home or establishment entrances and frontages uncustomized, anonymously undifferentiated, accepting the “issue” doorway and marker, etc. The city can either choose to accept this, so long as the public premises are kept neat and tidy, or set minimum standards for decor and landscaping, and, where these are not met, making the improvements itself to be paid by tax assessment on the negligent party - such is “the system” in Oak Bay, an affluent garden suburb of Victoria, British Columbia

Streets that serve food-production areas (farms) might be encouraged by tax law to provide adjacent small parks and garden spots for the public as well as roadside produce markets. Because there

are no natural lunar annual “seasons”, crop harvests can be staggered to occur every sunth (29.5 days). Fresh produce will generally be always available.

[If the settlement in whole or in part adopts a temperate climate with a hard frost sunth, in order to produce temperate zone fruits and vegetables, this would not apply. In this case, there could be two sunth-short frosts and two five sunth growing seasons annually.]

This said, however, in time, to serve growing demand for partially processed foods and the domestic meal preparation time-savings they represent, food processing enterprises may sprout up along these farm frontage roads. They will be supplemented by cottage industry home canners selling their wares in neighborhood markets. The farm road processing outlets will want to make their frontages as attractive as possible to potential customers. To do this they will use a variety of inorganic decoration methods, as well as landscaping and, of course, product display.

Doing Without “Commons”

The “commons” are areas owned by “no one” — thus subject to neglect, trashing, and cancerous blight — or by “everyone” and thus maintained at taxpayer expense. The difference between the two is nothing more than a budget-mandated choice tipped by the good or bad graces in which adjoining property owners are held at city hall. (who is most effective in greasing the palm). Instead the city should be concerned with utility and recycling systems and biosphere regeneration and maintenance. These city gut systems can be maintained by youth during tours of “universal service” keeping the tax-supported payroll to a supervisory minimum. City adoption of “commons” area creates the temptation to show favor and disfavor (e.g. to the rich and less-affluent respectively).

For areas available for planting and landscaping, both options can and should be avoided. This can be accomplished by individual or corporate ownership of larger plots, and individual and group adoption of maintenance chores in the upkeep of smaller plots. Groups can be of homeowner cooperatives or business / marketplace associations. Garden spaces of spice and salad-stuffs can be run by local grocer/eatery coops. Decorative garden plots can be managed by cottage industry market coops placed within or alongside them.

The model for this is the spreading adopt-a-mile programs one sees more and more along the approaches to cities and towns in this country. Individual and group self-pride and good-natured rivalry combined with design talent and maintenance energies can lead to a very high average state of both adopted plots and the larger privately owned plots within the various street cylinders. Wealth, of course, will “out” and the adopted “commons” of more well-to-do areas will inevitably be, on average, more luxuriant and decorous, than those in lower income areas. Wealth, however, has no native monopoly on inventiveness, hard work, art, and ingenuity - these are the great levelers.

Local Sign and Advertising Media

Even without such terrestrial standbys as paper, cardboard, wood, plastic, and organic base paints, Lunan proprietors and entrepreneurs will have a variety of materials with which to produce signs and ad boards. For relatively “permanent” signs (street names, house numbers, etc. and business names) backlit mosaics of stained glass and front-lit mosaics of glazed ceramic tile are two of the more decorative possibilities. Engraved or bas relief monochrome ceramics and concrete, and metalwork signage of various sorts will also work. Neon signs, using easily recoverable solar wind gases (banked by adsorption to the fine particles in the upper layers of the regolith soil overburden) such as argon, neon, xenon, and krypton will be feasible.

For transient and frequently changing signage and advertising, digital electronic display boards may be the solution, though vegetable-based water colors on recyclable craft paper are a less expensive option. If you come up with still more ideas, please share them.

Street Vegetation and Forestry

Purely decorative flowers, plants, shrubs and trees producing neither food nor fiber, herb or spice, dye stuff or pharmaceutical, will be hard to justify. An exception might be a memorial floral gardens partially fertilized with the ashes of departed pioneers. Such a special spot is bound to become a favorite backdrop for wedding photos etc. Some small luxuries are simply worth the cost.

Fortunately, some environmentally conscious landscapers are having great success on Earth making decorative and ornamental use of food-bearing plants and trees. Pioneers may enjoy no oaks or elms, pines birch, or cypress - but there will be orchard trees like apple, pear, cherry, orange, banana

and the like, and fiber-producing trees like Kapok. Others have suggested bamboo, useful for making informal furniture, scaffolding, etc.

Personally, while I can see a great role for bamboo on nitrogen and carbon rich Mars, the idea of permanent withdrawals from the costly, volatile-limited lunar biospheres seems an obscene luxury. Perhaps it can be allowed if accompanied by a discouragingly high luxury tax, high enough to pay for the replacement volatiles involved. Along the same line, wood may be so precious on the Moon as to make it a favorite jewelry stuff. Hard cherry and apple would be natural for such uses.

The major determinant, however, will be the design climate of the street-grid biosphere. If semitropical, i.e. never freezing, we'll see a completely different list of food bearing plants than if it is designed to freeze seasonally, in temperate fashion.

Possibly various neighborhoods could be designed diversely in this respect so that the city as a whole enjoys a greater variety. It is the more likely that climate will be a city-wide choice, however, and that some towns will be temperate, others subtropical, others tropical, etc. Variety at the produce market will then come from vigorous inter-town trade. Such differences in town climates will also generate healthy inter-settlement tourism, making possible welcome changes of scenery.

Many fruit and vegetable plants produce blossoms prior to fruiting, and such blossoms can take the place of purely ornamental blooms in adding seasonal dashes of color and beauty. Simple juxtaposition of useful plants of various heights, shapes, and shades of green will be pleasantly decorative enough as a free plus.

As to trees, we will see a definite change in maximum allowable height as the settlements grow and mature. The first "pocket forests" may actually appear in early outposts - caricature groves of "pet" bonsai trees. There will be room for little more.

Next will come dwarf orchard tree varieties which can be planted even in in-home atrium garden solaria. But as street cylinders of ample radius are built, we will have room for much taller fruit and fiber trees, even bamboo grasses.

Urban Street Wildlife

A biosphere without wildlife might be more efficient. But it would fail utterly to teach and remind young settlers of the host planet, teeming with wildlife, into whose midst the human species emerged. It will be both more educational and more morale-boostingly healthy to have some wildlife, however sparse and token.

The worthiest niche will be for pollinators. On Earth, these include honey bees, hummingbirds, some butterflies, and some bats. Their presence will give delight to many, as well as teach how real ecosystems work. Where plantings are in soil rendered from carefully aged regolith with the assistance of microorganisms, earthworms will introduce yet another phylum, yet another example of life's tremendous capacity for diversity.

A small captive flock of slow-breeding flamingos might quickly establish itself as the popular town mascots without devouring too much recyclable biomass. Certainly such animal mascots would cost the settlement orders of magnitude less than would any human mascots of some monarchy!

If there are open water canals making use of reserve water in process of treatment for recreational use, these can be stocked with both game and decorative fish (e.g. trout and poi). A large aquarium would serve even better to teach and remind youngsters how life began, in the oceans. We hope to speculate more on such options in another article.

The Street Plays Host to City Life

The first settlement streetscapes will be pretty drab. Few decor and landscape options; little variety in apparel; a paltry selection of consumer goods, mostly of crude "experimental" quality. As settlement industry diversifies in search of an ever longer list of export goods, new materials for building and crafting and artwork will appear, new finishes, new colorants, new tools, new methods. (Bear in mind that anything the settlers produce for themselves can be exported at a price advantage to other in-space markets.)

[MMM # 3 MAR '87, "Moon Mall"] [MMM # 77 JUL '94, p. 8 "Cottage Industry"]

Variety and diversity will grow exponentially as afterwork cottage industry activities arise to serve the unquenchable thirst for the custom, the different, the personal, the truly beautiful. Street

markets, at first hit and miss in both times open and space will become regular, then permanent, and grow from flea market caliber towards a satisfyingly department-store-like spectrum of selections.

As versatile food crops increase in number, menus and cuisines will diversify and a wide range of interesting eateries and the odors associated with them will soon become taken for granted. As the variety of musical instruments fashionable from lunar materials grows, the number of good street ensembles will mushroom, as the number of a capella singing groups diminish (e.g. barbershop quartets).

[MMM # 3 MAR '87, "Moon Music"]

The more consumer products, the greater the volume and variety of discard objects. Reuse and recycling sorting bins and exchange marts will grow.

[MMM # 34 APR '90, pp. 3-5 "Recycling"] [MMM # 66 JUN '93, p. 9 "Encyclobin"]

Because capital production equipment as well as service facilities to be enjoyed by all will be expensive, less will go farther if used and enjoyed, as the case may be, around the clock. The settlement will work three staggered shifts without chauvinist preference for one over the other. With the solar clock set on 4 weeks instead of 24 hours, different streets and whole neighborhoods can have their own day/night lighting cycles.

[MMM # 43 MAR '91, p. 4 "Dayspan"; "Nightspan"]

The corollary is that the neighborhood-joining commercial, market, dining and entertainment street areas should be alive, vibrant, and interesting around the clock. Market stalls and cottage industry shops might be time-shared by coop members, or their goods sold round-the-clock by caretakers on a consignment basis. And always, the street will be the place to indulge in the universal pastime of people watching.

Whatever the part of 24-hour lighting cycle, settlement streets will take on a different personality and ambiance depending upon whether it is dayspan or nightspan out-vac. It is not only a matter of the availability or not of magically healing sunshine. The number of people on the street, their energies and moods, and the quantity of cottage industry goods available will all cycle with the local 29.5 day sunth. Many production employees will change from energy-intensive to labor-intensive jobs as night falls and with it the total available electrical power. Street activity cycles will follow suite.

[# 28 SEP '89, p. 3 "Choice of a Three Village System"]

Some landscaped areas will sport park benches for shoppers and workers on break to take a respite. Urban pocket parks work best if they are not secluded. People want to relax, yes, but such relaxation is enjoyed the more if it is in a peaceful spot in the full midst of the vibrant city bustle all around. Check and see: well-intentioned secluded urban parks are almost always relatively unvisited.

The Unfinished City

"Praise be the darkness, and Creation Unfinished!"

Ursula K. LeGuin in "The Left Hand of Darkness"

If any of us came into the world to find it, its culture, its civilization and cities "finished" we'd be at an intractable loss to find personal meaning or significance to our lives. It is because the world and the city is unfinished that it is both breeding ground for evil and an opportunity for good.

Urban planning must always remain tentative, confine itself to infrastructure and resist the temptation to divinely proclaim the details, stifling individual initiative and expression, suffocating the vibrant vitality that comes from unexpected spontaneity. The city is livable only to the extent that for each of us there is an opportunity to contribute our own individual "brick(s)". The off-Earth "Xity" [= a city that has to concern itself with creating and maintaining its own biosphere] is a shared undertaking of unprecedented challenge and scope.

As such the proposition to establish a "Xity" will attract architects and city-planners who would play god, deciding everything, reducing all who shall ever after live therein to lives the more meaningless because of the lack of opportunity to help finish the unfinishable city. It is only the unfinished city that lives, that is alive. Future off-planet cities, whether they be on alien surface scapes or within O'Neillian rotating constructs, must begin life only partially determined. This is a challenge foreseen, to be sure, by no science fiction/fantasy artist with whom I am familiar. Their cities are all uniform in architectural style and plan, all new (rather than a mixture of new and old) and inevitably gleaming, as if created not bit by bit like living world-challenged things, but all at once like some bauble in a bubble.

Enthusiasts captivated by such untrue-to-life artistic renderings may not make the best pioneers. The frontier will always have rough edges and the pioneer's calling is to smooth them down, one at a time. There will be no abracadabra cities out there, just frontier towns whose inhabitants will find their lives enriched with the real life chance to make a difference, to help finish the never finished.

Examine yourself, score yourself, and take another look! Because it is so very unfinished, the frontier settlement or city will be most rewardingly livable. To be sure, the great megastructure cities such as O'Neill colonies, proposed domed craters, vaulted rilles, the main "plaza" structure depicted by Rawlings in Ben Bova's "Welcome to Moonbase" are visually alluring and inviting. Their high ceilings allow expansive vistas within which individual dwellings and other buildings can be built using familiar construction methods to create Earth-mimicking urban environments. But despite their postcard-worthy panoramas, such fixed-size cities will quickly become vitality-suffocating unless they are somehow able to expand in modular fashion (as in the Prinzton study of vaulted rille sections built as a series of villages in multiples of three*. The discussion is moot, however, for in the near term, only modular lunar and space settlements can have realistically affordable construction and early occupancy thresholds. **<MMM>**

MMM #112 - FEBRUARY 1998

The Out-Vac Sculptor

By Peter Kokh

Human acculturation to the Moon involves more than just using lunar materials to build with and express ourselves creatively within tight-hulled mini-biosphere settlements. There is no need to confine the material evidences of human interfacing with the Moon within "reservation" "ghettos". We will also build roads, roadside inns, solar flare sheds, repair garages, outfitting supply general stores, and so on, in between settlements. We will build scenic overlooks along crater rims and other high points. There will be rural retreat houses, and small rural "intentional communities" or communes (we've suggested the name "tarn" from the Old Norse for a small mountain lake in its own isolated mini-basin or cirque - after all, such rural outposts are isolated oases with their own water reserves.)

Over and above all this, it will be legitimate for Lunan artists to express themselves creatively in the wide open spaces of the out-vac in a way which both complements its "magnificent desolation" and which also celebrates the new stepmother-stepchild relationship of Mother Moon and the new frontier human settlements and communities. Out-vac sculptures will proclaim the mutual adoption of both for one another. In many cases such 3-D creations will serve useful functions. Both raw "magnificent desolation" and human artifacts give glory to the Creative Energy at work in the Universe through everything, through each according to its nature.

Available Sculpture Stuffs

Sculpture comes in many forms: carvings, castings, assemblages, and simple arrangements of found items. Different materials can be used or worked in varying ways to form 3-D creations. What lunar available materials might a transplanted sculptor pick for various large-scale out-vac art creations? On hand, usable almost as is are these:

- Boulders, rocks, and breccias (rock composed of angular rock and glass fragments melded together): Large boulders can be used as landscape accents, or, engraved, as milestone markers, sign posts, etc. Smaller rocks can be used as is, or cut into blocks or slabs, even polished. Question: would their surfaces sparkle with fluorescence under black light?
- Simple mold-sintered regolith, in various natural regolith shades perhaps gathered from remote sites to provide enriching contrast with the local soil.
- Sintered mold-shaped low-performance creations of iron fines. These fines are fairly abundant in lunar regolith from which they can be harvested with a magnet. Sintering does not impart great strength, but out-vac sculpture creations which undergo only dayspan/nightspan thermal stresses should endure.

- Iron castings and wrought iron, prior to the availability of steel alloy ingredients might make durable sculpture materials outside rusting atmospheric of settlement interiors. (Items could be steam-rusted in pressurized studio compartments before being placed in permanent out-vac locations as an option if rust color is desirable.)
- Native glass spherules might be used in various surface treatments in sun-catching ways.
- Manufactured glass of various crude to refined formulations: poured, cast, blown, reinforced with clear or colored fiberglass, prisms and colored sun catcher creations; mirrors.
- Cast basalt, a onetime actual industry in Central Europe which could easily be pre-pioneered anew in states like Oregon, Washington, Idaho, Hawaii, etc.
- Ceramic pavers, glazed or unglazed
- Gunite: a mixture of lunar cement, and rough-sifted regolith with glass and small aggregate inclusions, sprayed over forms to create lightweight simulated lunar rock. Terrestrial Gunite™ is used to make lightweight "rock" outcrops in zoos, for example. (may be the standard faux rock in space settlements).
- Cast magnesium (unalloyed, dangerously reactive in oxygen), where we would use bronze on Earth.
- Aluminum, steel, and titanium, once these are produced on the Moon.
- Welded salvage scrap metal and abstract or form-suggestive junkyard creations, using discarded metal objects originally forged on Earth.

Some Out-Vac Applications

Sculptures and sculpted works might be placed in the out-vac for a number of reasons. For the enjoyment of travelers, "sculpture gardens" would provide welcome interest in areas where the native "scenery" is especially monotonous. On Earth, we find sculpture gardens on the grounds of museums and, in some states (e.g. Nebraska) concerned with interrupting soporific driver fatigue, boredom, and mesmerization with the road, at scattered highway waysides. But these are within the given biosphere, enjoyable in "shirtsleeve" comfort, as is everything on Earth. So such use provides no easy parallel on the airless Moon. There, travelers are not going to don individual spacesuits to exit their protective motor-coach or other vehicle just to peruse a bunch of sculptures. Too much hassle.

Like façades of corporate headquarters deliberately sited alongside busy interurban freeways, and meant to be enjoyed in fleeting glimpses, such "freewaytecture" provides a better model. Items in a lunar out-vac "sculpture garden" could be placed in a well-spaced row, say in a "boulevard median", to be enjoyed in quick glances out their coach windows by people on route from spaceport to settlement gate and vice versa. Deliberate distractions of this sort would seem especially appropriate along stretches with little "competing" natural scenic attraction. The sculptures chosen would have just enough detail to be appreciated on the fly, yet enough to be enjoyed over and over on repeat passings. This generalization would seem to be pertinent for all out-vac sculpture.

Monuments commemorating historic sites (first "overnighting" on the Moon, etc.) and historic events could aptly be set out on the naked surface along well trafficked corridors, aimed at catching the eye just long enough to stir the soul, no more. Of course a monument could be tall enough, and/or set on high enough ground, to be observed with more intent interest for an extended time and for many miles as vehicles approached the site, passed by it, and then receded.

For example, a very large scale sun-catching monument of polished stone, polished aluminum, mirrored glass, clear glass, or prism shape, etc., erected to celebrate the achievement of independence by the Lunan Frontier Republic might be placed atop a mountain peak that stands prominently out from other nearby surface features from well beyond the general horizon. Mt. Piton, an isolated 7,500 ft. high massif in ENE Mare Imbrium is one such example. From atop this perch, a monument such as we've described could be seen above the horizon for many tens of miles from a busy road passing to its sunny south between Mare Imbrium and Mare Serenitatis, where it could mesmerize passersby. Such a road could very likely become the busiest east-west travel corridor on the Nearside. (This previously published suggestion is not mine. Ben Bova's?) Again, freeform and abstract design would work better than anything demanding closer inspection to be fully enjoyed.

Decorative options combine with utilitarian function to provide many other non-commemorative chances for out-vac sculptors to express themselves and delight others. Graded roadways could have their right-of-way edges clearly demarcated by rows of gathered smaller boulders, rocks, and breccias.

These could be left natural, art limited to selection and serial arrangement, or they could be cut and polished to better catch headlights during nightspan, or along shadowed stretches during dayspan. This both decorative and utilitarian technique could then be applied to the slopes of road cuts, embankments, and retaining walls as well, which could be covered and/or stabilized with cut rock "pavers".

Question: certainly some Apollo moon rock researcher has tested both moondust and various rocks and breccias, intact or cut, for fluorescence in "black light". [If any reader is familiar with such research, would they please acquaint the editor with the results?] If this fluorescence exists and is high enough, maybe black light headlights would be more appropriate along lunar highways, at least during full nightspan, than normal halogen or other visible light lamps, especially on the farside, out of reach of "Earthlight" (which should provide illumination enough). After all, the roadway is unlikely to hold other obstacles, and if it did, radar, more easily linked to automatic warning or steerage correction devices) could more easily and spot these and more accurately access them. On Farside, the use of black-light only would allow drivers and passengers to enjoy the full splendor of the intensely star-spangled lunar heavens.

Early lunar highways, when they come to rille valleys too long in either direction to detour around without major inconvenience, will probably simply angle down one slope and back up the opposite one. Eventually, in high traffic areas, more expensive bridges and causeways may be justified. While these will be basically utilitarian in their design, there will still be several basic structural design choices, as well as elements of each design not constrained by function. Such elements will provide sculptural and decorative opportunities: side bumper walls, lampposts, mid-bridge scenic turnout markers, etc. Roadside signposts in general (milestones, junction directions, "Place of Business" signage), offer decorative occasions beyond the simple "rock pile and post" wherever they are put.

Out-vac sculpture can be Government or Sponsor-Commissioned or privately financed, even artist-donated. A prime example of an opportunity for privately financed sculptural decoration will be the home-pride and/or image-conscious need felt by some to mark the exterior regolith mound shielding their own home, neighborhood, entire settlement, or their corporate headquarters or other place of business in some distinctive fashion. This can be as simple as raking patterns. Or distinctively colored thin top-layers could be applied (e.g. very dark ilmenite-rich soil, calcium oxide lime, to suggest two cheaper choices). Or the mound slopes could be accented or even fully paved with cut rocks or molded cast-basalt tiles, even faux "shingles" etc. [See MMM #55 MAY '92, p.7 "MoonRoofs".] Luxuries like this will obviously be more common in close proximity to surface roads from which they can be appreciatively noticed. This would fit the sad but common dishonesty on Earth where only traffic facing façades are given special attention.

Out-vac sculpture of all these sorts, and of kinds we have not imagined, will allow frontier pioneer artists to put a human touch on the lunar surface in the areas where human presence has been or is being securely established. These artifacts will proudly proclaim a clear message:

"This magnificent desolation is ours. It is home."

The role of lunar-derived art forms and crafts in making settlers feel at home will be major. **<MMM>**

MMM #136 JUNE 2000

A Fresh Try at "Regolith Impressionism"

By Peter Kokh

DAWN

It was a personal high point for me, back on September 29th, 1994, when I produced the first piece of an art form that had never before been tried. "**Moon Garden #1**" was painted on the reverse side of an 8"x10" (20x25 cm) glass pane, foreground first. But that was not the revolutionary part.

For pigments, I used metal oxide powders -- nothing special about that! But instead of an organic solvent as a medium, I tried mixing these powders, in less than teaspoonful batches at a time, into sodium silicate. Sodium silicate is a liquid so long as it is not long exposed to open air. What's special about it is that this compound is the only known inorganic adhesive. It was a hunch, and it worked. After all, there are no known inorganic solvents, save water.

What's so unique about all this? The success of this experiment meant that Lunan Pioneers could in time express themselves artistically with paints, all of whose ingredients could be produced from raw moondust. Even though the actual source of all my ingredients was quite terrestrial, they could all be found or produced on the Moon. Lunans need not be dependent on expensive art media materials imported from Earth! One small step for a man, one humble but bigger step toward Lunar Self-Sufficiency!

This project was possible only with the help of a friendly chemist at a professional pharmacy not far from my home in Milwaukee -- Laabs. He was very patient and helpful when I brought to him requests for bottles of this oxide, bottles of that. It all began when I mentioned to him my idea, and he told me that he could get sodium silicate for $10 a gallon.

The stuff is hard to work with. The "paints" are viscous, making "planned" detail very difficult, even with tiny artist brushes. Inevitable skips on the glass did allow me to fill in with a contrasting color or lighter or darker shades on the flip side, and that did provide "detail" -- if not quite according to plan.

So I began to call the new art form "**Regolith Impressionism.**" "**Moon Garden #1**" got a write up in the Jan/Feb 1995 issue of Ad Astra, bimonthly magazine of the National Space Society. Over the next year and a half, several new paintings were produced.

I tried in vain to spark the interest of other artists with more creative and artistic talent than my basement workshop schooled hands. I even set up a shadow club: "L.A.A.M.P. - Lunar-Appropriate Art Media Pioneers" and received two $10 memberships. Several more persons became interested, but to my knowledge, no one else has either had the patience to try, or been able to find locally convenient sources of the ingredients I had used.

LIMBO

Then came the letdown. One by one, after several months, an at first hardly noticeable deterioration set in. The paint began delaminating from the glass. The first painting is the only one I held on to, giving or selling all the others. You can still see tell the outlines of what was there, but more than a quarter of it is bare glass. Others reported the same fate for the paintings they had.

I didn't know what the problem was. A film on the glass? Preventive steps were in vain? Was sodium silicate only a "temporary" adhesive? I wasn't able to find sources on its performance. I stopped trying.

FRESH START

In early 1999, at the email request of NSS headquarters, I helped Jason Orloff, a chemical engineering student at the University of Wisconsin in Madison, start the Wisconsin Chapter of the young Mars Society (not that HQ knew that that would be the outcome!). We quickly picked up a dozen or so regular members. This spring (2000) at a meeting in Milwaukee, during a Show & Tell session, I explained what I had tried to do with these paints. Ron Zdroik, a commercial artist who is part of the group, suggested I try again -- after micro-etching the glass with wet metal oxide paper. It occurred to me that if this proved to be the remedy, that I might try a wet rag dipped in lunar simulant, of which our local NSS chapter (LRS) had a small supply. Now if that worked, it'd be a treatment that could be used on the Moon.

I determined to try afresh. Here was another opportunity -- a chance to do a fresh painting to pack in as a bonus. "**Red Sands, Blue-Green Dreams**" was done on an etched 5"x7" glass pane, with the central marsscape continuing into the "terraformed" blue green matting. Time will tell if this one endures. At least it may inspire. <PK>

"The innovator has for enemies all those who have done well under the old conditions."
- Machiavelli

MMM #138 - SEPTEMBER 2000

THE BLACK SKY "BLUES"

Coping with "Black Sky Country"

By Peter Kokh

Foreword

On Earth we enjoy a brightly illuminated sky. If it isn't clear and blue, the clouds are bright. The darkest storm cloud is far brighter than pitch dark.

On Mars, the sky seems to be "salmon" hued, though there is one researcher who insists that this is only the case during and after dust storms. The point is that on Mars, as on Earth,, the daytime sky is a source of diffused ambient light that makes viewing the landscapes easier. Earth and Mars are "bright sky worlds," a gift of their atmospheres.

On the airless Moon, however, the sky is pitch black during dayspan. In the glare of the unfiltered Sun the naked eye cannot see even the brightest star. During the near-side nightspan, Earthlight will cast a glare from up to eighty times as bright as that of full moonlight on Earth. Even a partially lit Earth will also blot out most of the stars. Only on the lunar farside, forever turned away from Earth, do the stars come out during nightspan - and with a brilliance we cannot imagine. But at no time anywhere on the Moon is the sky itself "bright."

We've all grown up with the night. We don't mind it. Nighttime darkness is only temporary. With dawn comes welcome visual relief. On the Moon, that relief never comes. Our pioneers will be transplanting themselves to "Black Sky Country." And that can have long term psychological consequences.

With the black sky even at "high noon", the contrast volume between surface and sky is intense. Shadows are bottomless visual pits. This will cause some eyestrain. Of course, this will be more of a problem for those who spend a lot of time out on the surface - in the "out-vac". But it will affect those who spend most of their time in pressurized spaces as well: in what they see through various types of "windows" (visiscreen, periscopic picture windows, etc.); it may affect "skylights" as well.

Coping with Black Skies

To the extent that the "Black Sky Blues" do become a subtle morale problem, and this may differ from individual to individual, ways of providing deserve serious attention. Here are a few, we can think of for starters (and we invite readers to send in additional suggestions):

- **Electronic Windows**

  Whether we call them telescreens, visiscreens, or something else, electronic images of the surface scene outside offer , for good as well as mischief, the opportunity to be manipulated. The viewer may be able to select a sky color and brightness to his or her liking. The viewer, much like an Internet browser, would then "interpret" the black areas at the top of the picture accordingly. Pick a light gray to go with the moontones, or a smoky blue. Or, if you're a visiting Martian pioneer, a dusty salmon. Those homesick for Earth can pick a brilliant blue. The idea is not to deceive oneself but to prevent eyestrain - if it has become a personal problem.

- **Spacesuit Helmet Visors**

  Would it be possible to give the visor some differentially reflective coating that would "brighten" the sky, even if just a bit, without interfering with clarity of visibility of the moonscape? We throw out the challenge. If this proves feasible, could we do something similar with regular windows and periscopic picture windows ("Z-views")?

- **Skylights & Clerestory Windows**

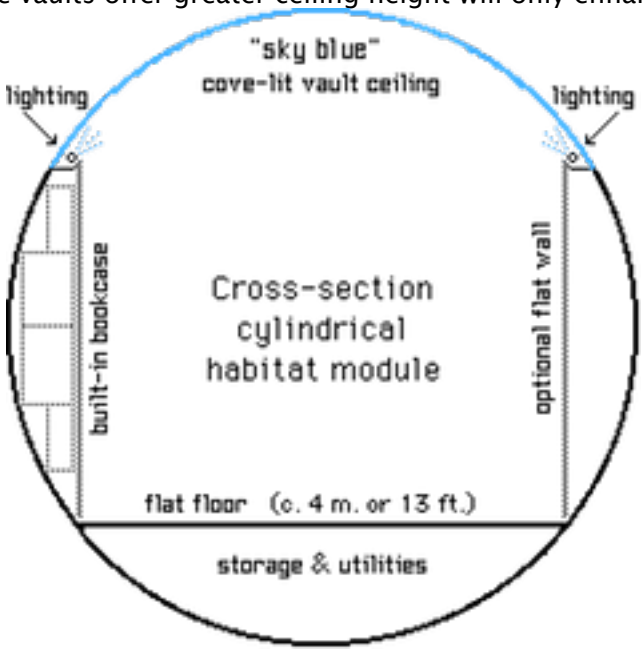
  On Earth, water vapor in the atmosphere scatters the suns rays so that light seems to come uniformly from all directions. Our atmosphere is a natural "diffuser" with a bluish cast. For those windows meant to bring in light but not necessarily the views, could we produce some sort of frosted and translucent, but not transparent, glass pane that will not only let in sunlight but appear itself to be bright, giving the illusion of a bright sky beyond? Again we but throw out the challenge. One might experiment by holding up various kinds of existing glass and diffusers to a streetlight against the dark nighttime sky.

Windows, skylights, and clerestories of this type will be desirable not just for private homes but for sunlit pressurized streets and other "middoor" spaces, sports facilities, highway waysides, etc. Passive light scattering panes to the extent that they present a satisfying illusion of a bright sky could become standard, or at least common.

Without real experimentation, we would not pretend to guess what will work best. But we should be trying a lot of things, including foamed glass, aerogel, special coatings or laminate layers, etc. Meanwhile, this standby:

Some may not want to wait for such tromp d'oeil developments, or disdain them as dishonest. And it may turn out that none of these suggestions will be possible to realize in a truly satisfying way.

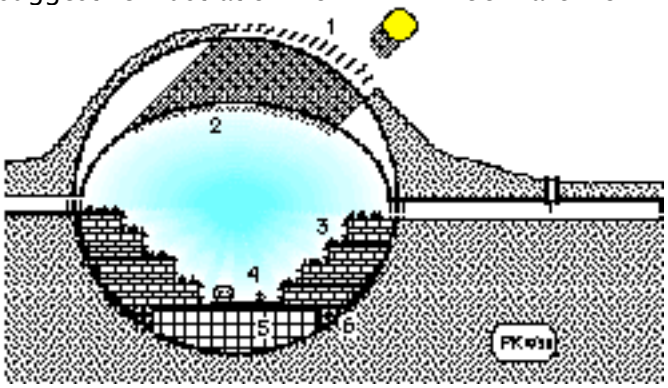
There is another, simpler way. Pressurized habitat structures and modules will commonly have curved surfaces. We'll need to install flat floors, of course, but the curved ceilings of spheres, cylinders, and toruses present an opportunity. Finish them with a light-absorbing matte texture and illuminate them with cove lighting. Give the finish – or the light source – a subtle blue cast, and Voilà, the appearance of blue sky. That these vaults offer greater ceiling height will only enhance the effect.



We can in effect, recreate the familiar blue sky indoors on the Moon. On Earth, where all we have to do is step outside, this hardly seems like a worth-while extra expenditure. On the Moon, suggestively bluish cove-lit vault ceilings may become the norm.

Cove lighting, especially if it is really "sky-bright", will reduce the need for other lighting: floor and table lamps, wall sconces, and especially ceiling lights and chandeliers. Strong indirect ambient light reflected everywhere off the vault ceiling from cove light strips hidden from view will create a positive psychological "atmosphere".

It's understandable if some residents might prefer the flat, white ceilings they are familiar with on Earth and to get their daily dosage of blue skies in common "middoor" spaces such as pressurized roadway tubes. Below is a suggestive illustration from MMM # 53 March '92.



THE RESIDENTIAL STREET ('HOOD) AS THE MODULE

Cross-Section of cylindrical module 40m x ?00 m: [1] shield louvers let in sunlight; [2] suspended sky-blue diffusing "sky" - air pressure same on both sides; [3] terraced residential housing with rooftop gardens; [4] thoroughfare running the length of the (neighbor)'hood; [5] light industry, shopping, offices and schools; [6] conduits for utilities.

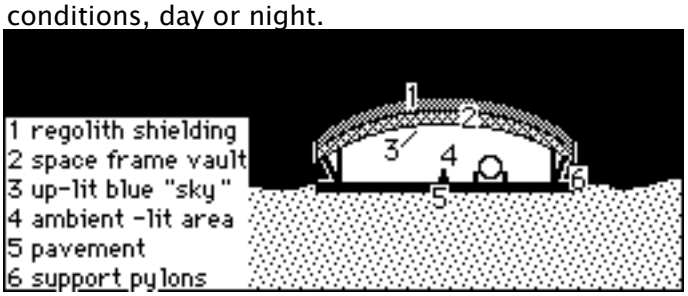
At first, roadway tubes will be of a much more modest scale, of course. But other "middoor" spaces (pressurized common spaces neither inside private quarters nor "out-vac" on the surface) such as school recreation spaces, public squares, sports arenas, and "park and picnic areas within agricultural modules all are prime opportunities for faux blue sky ceilings.

During the two week-long nightspan daylight (on an artificial 24 hour schedule) could be simulated by using electric cove lighting aimed at such vault ceilings. During the equally long dayspan, sunlight could be indirectly channeled by mirrors to reflect on the vault-ceilings full-time, or shuttered to simulate night conditions on a 24 hour schedule.

Blue Sky Simulations Out-vac

What about simulating blue skies outside the settlements, out on the surface? This might be very desirable for frequent inter-settlement travelers, truckers, and others whether they spend a lot of time in such conditions or not. Certainly, one could design emergency solar flare shed vaults and other covered roadsides, even if unpressurized, lit from below, thus providing "bright skies" of a sort, whether they be blue, white, or light gray.

One can foresee a day when many thousands of people live on the Moon in several settlements. There might then be one or more heavily traveled surface corridors. These could be covered with shielding vaults lit from below, open to the vacuum. Such lunar "superhighways" would make for safer, more comfortable driving conditions, day or night.



Someday, settlements may be built within great megastructures with soaring ceilings. These too could be designed to offer bright blue skies. But meanwhile, the use of cove-lit vault ceilings in habitat and other interconnected settlement modules will go a long way to shake those "Black Sky Blues" or at least help inoculate the settler pioneers against the accumulative visual deficits of the "magnificent desolation" of the lunar terrain.

But hopefully, someone will pick up on the other challenges we've put forth, of individually tunable "browser-like" video screens, special light scattering glazing options, and smart helmet visors.

The "Black Sky Blues" is something we need to take seriously. It poses an acculturation challenge unique to the Moon and other airless worlds which future Martian settlers will not have to face. <MMM>

MMM #139 OCTOBER 2000

Tramp Art

By Peter Kokh

Artistic Resourcefulness

No amount of access to materials and tools can make up for a lack of talent. Nor, on the other hand, can lack of access to preferred materials and tools prevent resourceful expression of creative instincts. The artist in a person will surface, be his or her talent schooled and cultivated or not.

Natural artistic creativity and crafting abilities are widespread in all human populations. And there are abundant examples to demonstrate that the incidence of such talents do not correlate with either economic or social accidents of birth. In fact, it is the expression of artistic feeling by those without access to refined media and special tools that allows us to get a fuller grasp of just what art is, of just what artistic talent is.

Another factor that comes into play is the strong desire of artists to distinguish what they do from the work of others. Younger artists are ever on the lookout for new materials on which to work, for unsuspected or underdeveloped "talent traits" of old and familiar materials, for other ways of developing their own unique, special "style." Thus, amazingly, even in affluent cultures, many artists display the resourcefulness and creativity of "Tramp" artists. To see for yourself, just go to any art festival.

"Tramp Art" is a name given to a particular art form practiced by "hobos" plying the American railroad lines. Using common pocket knives, they carve intricate patterns into any wooden boxes, crates or broken wood pallets found along the tracks wherever they roam. Prime examples of this art from have come to be highly valued by collectors. "Tramp Art" is not a term used disparagingly.

But our purpose is not to examine this art form in itself. The emphasis is clear: tramp ART. "Tramp" is a word that stuck, but it could just as well have been "Hobo", "Homeless," or "Have-not."

Many art forms have been practiced through the ages using "found objects" for raw materials out of which to give form to one's artistic visions. Folk art, pop art are similar. So are the "cutesy" crafts that use plastic pill cups, popsicle sticks, empty coffee cans, and other commonly available and inexpensive use-them-once-and-throw-away detritus of our consumer civilization.

Even empty steel drums have been put to use by West Indies musician craftsmen who carefully reshape their ends to produce some of the world's most beautiful folk music! We've all heard the maxim: "necessity is the mother of invention." It applies to artists, craftsmen, and musicians as well.

Meanwhile, back on the Moon and Mars. ...

On the rough, rugged, and raw early frontiers of the Moon and Mars, pioneers will in time learn to make refined media out of local resources: regolith, mining tailings and processing byproducts. They will produce pure metal oxide powder pigments for use in paints, glazes and art glass; special claystuffs for ceramics: special alloys for metal sculpture and jewelry. But these preferred materials will become available as byproducts of industrial mining, processing, and manufacturing operations. Some of these byproducts will appear early on, others much later.

In the dawn period of lunar outposts and settlement, artists and craftsmen will have much less to choose from: raw regolith (carefully gathered for shade and hue); glass spherules; aggregate breccia pebbles and rocks. But they will also have some "value-added" materials to challenge their instincts:

- packaging left from items brought from Earth
  - ◇ containers - drums, boxes, crates, tins, etc.
  - ◇ separators, dividers, fillers
  - ◇ wire, strapping, foil
  - ◇ filler stuffings
  - ◇ rope, twine, string, rags
- "trash" from consumables
  - ◇ tin cans, bottles, jars, caps, lids
  - ◇ boxes, cardboard, paper, plastic film
  - ◇ worn clothing - "rags"

Now a lot depends upon how intensively and thoroughly the lunar operation is planned. If we do it right, all packaging materials, consumer or not, will be deliberately chosen, formulated, or designed to provide cannibalizable manufacturing stuffs not easily found or produced in the early settlement from the local materials.

Some examples:

- copper (and brass and bronze)
- stainless steel
- lead, zinc, gold, silver, platinum and other industrially strategic metals
- reformable simple plastics: stuffing peanuts etc.
- biodegradable, nutrient-rich paper & cardboard

We've previously talked about this critical opportunity on several occasions, notably in MMM # 65 MAY '93, pp. 8-9 "Stowaway Imports". It all depends on who is in charge of the operation. If it is government, we will not see much of this kind of caring foresight. If it is business and industry, of necessity trying to leverage every opportunity to ensure profitability, preplanning of this sort may be intense. The pace and scope of future industrial diversification and growth will be at stake.

In this case, because the emphasis will be on meeting strategic manufacturing needs,the amount of scrap or leftovers available to artists and craftsmen will be less. But the law of diminishing returns as applied to such foresight efforts guarantees that there will still be some.

Looking ahead, we cannot predict the kinds of surplus items that will be available on the frontier for the use of artists and craftsmen and musicians. But perhaps planners should keep their needs in mind to include some packaging stuffs (e.g. food and other "consumer" packaging) that can be carved, reshaped, sculpted, decorated, etc. Input from artists of demonstrated resourcefulness on Earth will be helpful in this regard. Even durable goods with limited lifetimes can be designed to be made of materials the artist or craftsman can use. And not to forget worn clothing for the fabric arts!

Those with artistic soul will not suppress their need to create until more sophisticated stuffs and tools become available. Any discarded items that patient artists can find a way to shape, paint, mold or otherwise modify or assemble to express their feelings will do just fine. Arts and crafts based on pioneer resourcefulness will lead to well developed space frontier folk art forms highly valued by collectors. In the meantime, it will be much appreciated by the early pioneers of whatever "status."

By whatever adjective -- tramp, cargo, folk, pop -- frontier arts and crafts will always thrive. It is, after all, part of being human to put the stamp of one's soul on the material counterparts of existence.

Past MMM Articles on Arts and Crafts

MMM # "Moon Mall"

MMM # 22, FEB '89, p. 6, "Hair"

MMM # 23, MAR '89, pp. 5-6 "Tailings"

MMM # 26, JUN '89, p 4, "Toy Chest"

MMM # 26, June '89, pp. 5-6, "ThermoPlastic"

MMM # 34, APR '90, pp. 3-5 "Recycling"

MMM # 55, MAY '93, p. 7. "MoonRoofs"

MMM #55, MAY '93, p. 8, "Shantytown"

MMM #77, JUL '94, pp 4-9: "Cinderella Style," "Furniture for the Lunan Homestead," "Upholstery Fabrics," "On the Wall," "Art du Jour"

Sculpture Stuffs

Sculpture includes more than objects which are carved or poured into crafted molds. Heterogeneous materials can be welded or bonded together or mechanically assembled into beautiful objects. Old bumpers and other junkyard auto parts plus imagination produce interesting and attractive pieces. In Mozambique, young sculptors have been welding the large supply of abandoned rifles into amazing pieces that are fetching top dollar. Scrap lying around and available at low or no cost is enough to energize the artistic creativity of frontier artists.

Depictive Arts

If it is prohibitive to import familiar art paints and painting substrates from Earth, frontier painters can carefully pour color sorted regolith fines and glass spherules into glass pane sandwiches not unlike the sand paintings done in the southwest. Collages of these materials small breccia will work. Once sodium silicate, the only known inorganic adhesive, can be produced, more options will open. As we start producing more secondary elements for formulating metal alloys, their oxide powders will be a great source of pigments for paints, ceramic glazes and glass stains. Even shorn human hair, in small strands and in powdered form, have been used to produce "paintings". An extremely rare art form, hair art might see a revival on the space frontier.

Fabric Arts

Packaging twine and rope and stuffing rags, along with worn clothing, and other fabric scraps will be enough to get frontier fabric arts started. We might encourage visitors and tourists from Earth to wear garments of desirable fabrics and patterns on the way out, to exchange for frontier-made apparel for the trip back. This practice would "sneak in" an affordable supply of fabrics that could not be easily produced in the early settlement. Worn clothing can be fashioned into colorful rag rugs, rag dolls, quilts, and patchwork apparel accessories.

Art Stuffs for Kids

Import packaging made of wax, reformable plastics, or fabric shreds will be one source of toy stuffs. So will many garden byproducts, considering the short life expectancy of most toys.

Imported Arts & Crafts Tools

Newly arriving pioneers might have an "heirloom allowance" so that they have relics of "home" to make life more rewarding. Thus artists could bring in special tools they need to practice their art - tools being much more important than materials.

Consumer Containers for Secondary Use

Consumer containers, whether frontier-made or made on Earth for use on the frontier, can be predesigned so that their material or shape makes them useful for an artistic "afterlife."

Craftable Imports:: modifiable utilitarian items

Some imported items will be assemblies of a "works" chassis, whose design rigorously follows function, and cabinets or casings that are a matter of style and preference. The optimum strategy for maximizing the industrial growth and diversification of the frontier calls for making the sophisticated parts on Earth and the less sophisticated, simpler parts where choice of materials is wide open entrusted to frontier industry.

Television cabinets are a poster boy example. They can be made locally of metal, glass, fiberglass-glass composites, ceramic or combinations thereof. In doing so frontier industrial designers can determine the finish styling. But we challenge them to come up with cabinets and casings that can both stand as made, but also support after-market customization.

Items with casings, cabinets, and handles that are imported from Earth in the early days before local frontier industries are able to contribute, can be designed with casings etc. that can be carved, stained, embossed, glazed or otherwise customized by frontier artists and craftsmen, for themselves, on commission, or for blind sales.

Art & Craft Stuffs from Early Industries

Every kind of industry produces waste of some kind. Substances that are melted produce slag made of immiscible elements that float to the top. Molten substances poured into molds produce splash out and spill over. Parts that are "machined" produce shavings, filings, saw and drill dust. All fragile products experience some breakage: ceramic pottery shards, and broken glass slivers and pieces.

- metal scrap: filings, shavings, cutoffs, dust
- slag & casting scrap
- ceramic shards
- glass
- concrete spillage
- sieve-sorted mining tailings

It will be general policy to recycle all such wastes back into the batch where possible. But in so far as we are dealing with materials from elements that are reasonably abundant, artists and craftsmen might be allowed to take what they can use of these stuffs from the bins of stuffs awaiting recycling. Of course, it will be up to the ingenuity and resource-fullness of the artisan to put such materials to use.

Bottle glass is commonly sorted for color and then crushed and tumbled before being remelted. These piles may be attractive sources to some artists. Glass mosaics or collages can be partially or wholly melted to produce pieces of great heterogeneity and diversity. One modern craftsman makes custom table tops in this fashion. Crushed glass, whether available in sorted colors or not, could be used as is out-vac to decorate sintered pathway pavers and to embellish regolith shielding mounds. Indoors they could be used as is in Japanese style rock gardens, or to fill the hollows of two layer candle jars. The possibilities are limited only by the imagination.

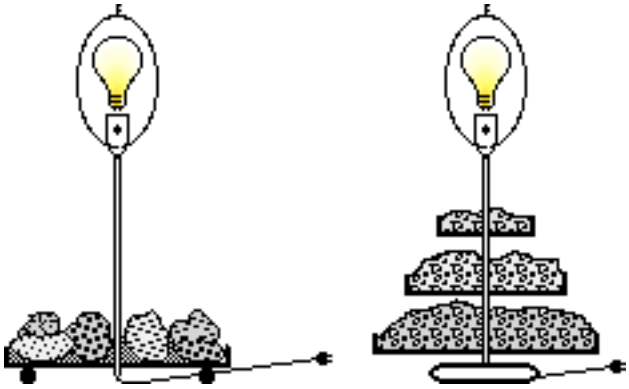
Recyclable post-consumer materials in any of these categories can be a source for the artisan. Scrap metal or ceramic fragments can be made into art.

Rock Decor

On the Moon, most rocks are breccias, angular fragments from older rocks, melded into clumps by glassified splashes from meteorite bombardments. They lack an even, homogeneous color or texture; each is a fascinating three-dimensional collage of minerals, an artifact made by Nature. Outdoors, such moon rocks can be used as borders for path-ways and approaches, or to decorate regolith shielding mounds covering habitat complexes.

Indoors, one could make interior Japanese style rock gardens with breccias, or cut them in half with a wet saw and polish them for display. (using a blacklight to bring out likely phosphorescent hues.) There should be a number of ways to mechanically attach sawn rocks to vertical "accent walls" without using wet mortar.

We could use rocks as well to give interest along with needed "weight" to bases of table and floor lamps. In the Moon's light one sixth gravity, we want to make tall items like lamps and drinking glasses bottom-heavy to prevent them from otherwise being easily tipped over. Lamp "kits" could come with trays of rectangular, hexagonal, or spherical shape, used singly or in tiers as optional accessories. The user would fill the tray(s) with interesting rock collections or sintered pebble-strewn moondust, or with other "collectibles".

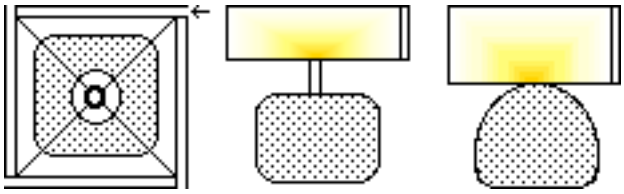


[NOTE: moondust contains a significant fraction of pure, unoxidized iron fines. To preserve the natural gray tones of the dust (and anything made of it) in pressurized, humid indoor conditions, remove as much of these iron fines as possible with a magnet. Or, to achieve a uniform rust tone shading right away, simply steam the dust as is.]

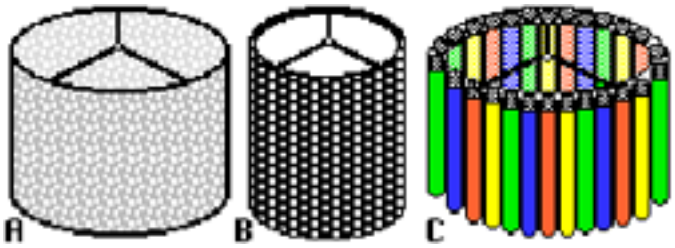
On Mars, their will be more kinds of rocks including sedimentaries, sandstones, granites, etc. While the gravity on Mars is more than double that of the Moon, it is still only three eighths that of Earth. So weighted bases will not be a bad idea there too.

Lamp Shades and Light Diffusers

On the Moon, where we'll want to leave our precious hoard of hydrogen, carbon, and nitrogen in the biosphere and food production cycles, we will be trying to avoid organic and synthetic fabrics and other materials. Fiberglass-based fabric lampshades are one option. Glass shades are another, there is already a lot of precedent; painted glass shades; Tiffany stained glass creations; cut, smoked, and etched glass shades. Earlier frontier artist and craftsman has many as yet unexplored alternatives. Below: a standard metal "frame" to be "filled" with any form of glass, metal, or ceramic panel set:



Overhead/side views of a lamp shade design of rectangular metal channel frame "shade starters" designed for slide-in panels of various materials, designs, textures, and colors: art glass; etched glass, pierced sheet metal, fiberglass fabric.



A) a "cracked" or frosted or regolith-blasted etched glass shade B) a punch-pierced tin can diffuser C) a "poor man's stained glass" shade: a metal frame with top rim accepting capped glass vials filled with vegetable-dye colored water: use all one color of the same or various shades, or try several colors, even a full rainbow of them. If the glass vials have molded texture or etched patterns for more interest.

Arts and Craft Stuffs from Frontier Farms

The constraints facing those who would use byproducts of lunar farms for the purpose of art or craft will be quite different to the situation facing their counterparts on Mars. For this reason, we will leave this engrossing topic for another article. Look for it in our annual Mars Theme Issue next March, in MMM # 143.

The Big Picture

When it comes to survival on highly challenging frontiers, whether it be for building and furnishing homes, farming, manufacturing things for domestic consumption as well as exports, resource-fullness and free spirited creativity creativity are essential. It is natural for pioneers to attempt to rely on what worked before - in their homelands. But all too often pioneers have found that the old doesn't work. Needed materials or tools may not be

available. Or the old products do not meet new conditions. It is then that inventiveness is necessary. And here we humans have never been found wanting

On the Moon and Mars, pioneers will face environments "orders of magnitude" more different from those that any pioneers faced before them. They should be prepared.

The topic of pioneer selection has come up often. Whether sponsoring agencies move to aggressively select volunteers according to some list of desirable traits, or whether we rely on the process of self-selection by interested persons fully brought up to speed on the challenges that they will face (we would prefer educated free self-selection!), it seems clear that a premium should be placed not just on skills, but as well on creative resourcefulness and inventiveness - not just for artists and craftsmen, but for the would be frontier population in general. There is simply no other way they will survive.

Given this monition, it would be foolishly self-defeating for settlement sponsors and planners not to invest in a very complete, diverse **library** of frontier, folk, and ethnic productivity around the world and throughout the ages. Now the vast bulk of past forms of art, crafts, farming methods, building techniques, transport aids, whatever ... will not be obviously translatable to the space frontier. But the spirit of resourcefulness, the inspiration of their creativity will! And that wealth of instances will fortify the pioneers with the evidence that "we have rose to the occasion before, we can do so now!"

Arts, Crafts, and Trade

Some "practical" persons with undeveloped artistic sensibilities will find all this to be of "low priority" if not needless frillage. Yet the economic impact of developing arts and crafts is enormous.

When it comes to homemaking, a very significant sector of any economy, we all want to express our own personality and tastes. And it is largely to artists and craftsmen, individually employed or in the service of manufacturers, that we turn.

Art and Craft creativity also produce distinctive goods to fuel trade between communities and countries - again for the same reasons. From the old days of the Hudson Bay Company, to the Sears Catalog to today's online internet shopping, it is these frills that underlie much of our trade prosperity.

Perhaps the largest growth sector of most affluent communities is travel. Why do we travel? Yes, to be able to enjoy first hand, nature in its various manifestations: wonderfully different coastlines, mountains, forests. But also to see cities and towns, homes, farms and castles that are special because they include or embody different examples of art and craft creativity. And we travel to shop -- where the wares and wears are distinctively fresh.

On such trivia rest a major fraction of the world's economic activity. Now what can be more practical than that? Yes there are more pressing and more immediate concerns" -- finding and processing the ores we need, building enough pressurized space, planting and harvesting enough food, getting a mini off planet biosphere to work in the first place! No one would deny that. But in the long term, if we don't take care of the "frills", we will neither have settlement worth living in nor a future that is ever more attractive and fulfilling.

In the early years, it will be various forms of "tramp art" that carry the load. <MMM>

MMM #146 - JUNE 2001

URBAN LOFTS & SETTLEMENT STYLE

Decorating Styles common in Urban Lofts may offer us a preview of Lunar Habitat Interiors

By Peter Kokh

"Lofty Ideas" is a weekly program (hosted by Katherine Stone) on Home & Garden TV (HGTV), a cable station offered by many cable networks. For those contemplating moving into an "urban loft" in a recycled old factory or warehouse, and for those just intrigued by the idea, this show gives a fascinating look at how a new generation of "urban pioneers" are making themselves very much at home, thank you, in the heart of cities once being abandoned in droves by residents not up to the new frontier challenges.

Lofts characteristically retain the relatively high ceilings of floors formerly given to manufacturing and warehousing. The interior surfaces of outer walls of lofts commonly consist of exposed brick, concrete, concrete

block, and other “industrial” materials, unfaced with plaster or drywall or paneling - those more “civilized” interior surfaces all-but-universal in more “traditional” residences: single family homes, town homes, condominiums, apartments, duplex flats, etc. Floors are commonly concrete or refinishable wood plank with a healthy hint of industrial wear and tear character worked in.

As purchased by their new occupants, lofts also most commonly boast exposed heating ductwork, plumbing pipes, and electrical wiring. And most new loft dwellers choose to keep it that way. To this shell which most lovingly accept, they may or may not add dividing walls (seldom full height), partial step up floors (a loft within a loft, e.g. for a bedroom) window and floor treatments and furniture and accessories. The extraordinary amount of highly personal creativity demonstrated in the half hour episodes of “Lofty Ideas” week after week is utterly amazing. For loft-aficionados, this is where it is at.

What has all this to do with future frontier settlements on the Moon? It occurs to me, that some of the “styles” we see emerging in this new residential medium, will also prove to be the most appropriate, the most efficient, and the most economical, once we are manufacturing modular housing shells on the Moon, for pioneers to turn into “home sweet home” oases in this magnificently desolate new setting. The reason is simple. Adopting the “as is” inner surfaces left by construction of pressure hull habitat modules removes the labor-intensive burden of giving them a faux finish, e.g. plaster or wall board plus paint or paper or paneling. The settlers need to save their free time for where it counts. Let’s take a look

The Shell (or hull)

The Moon is well-endowed with the all four of the so called engineering metals: iron (steel), Aluminum, magnesium, and titanium. Metal alloy pressure hull modules are a primary option for the lunar architect and module manufacturer. Lunar concrete, reinforced with steel rebar or glass fibers to give it strength under tension is certainly another. Glass fiber/glass matrix composites are a third. Surface treatment options available to the architect depend both on the character of the material, and on the manner in which the pressure hull is fabricated.

If the hull material is poured wet, and/or hot, into a prepared mold, its surfaces will take on the character of the surfaces of the mold into which it comes in contact and by which it is constrained. Molds can be smooth, textured,
embossed, or carved to create surfaces with special design characters.

In the case of concrete, if coarse aggregate is used, and the surface of the cured cement abraded somewhat, the aggregate with all the character and variation it may have, is brought to the surface. If this is not done, character can be imparted by the mold itself. We have all seen the clear telltale imprint of plywood forms on poured concrete walls. If the form, of whatever material it may be, is given deliberate texture or pattern -- and the possibilities are virtually endless --that texture or pattern will be transferred to the surface of the cured concrete.

This option can be used to endow surfaces with random or repetitive design patterns. I have seen a basement
wall of poured concrete that looks like brick, thanks to the pattern worked into the pouring forms. With two inches of
styrofoam bonded to the outside, the result is an instant “rec room-worthy” surface. Surfaces with leaf patterns, coarse crosssawn wood patterns, almost any kind of pattern is possible with concrete. Colored concrete sidewalk pavers with embossed patterns are also appearing. As are concrete shingles that look like cedar shakes. It seems that concrete can mimic almost anything.

We can speculate how we might fabricate habitat pressure hulls from glass composites, but until we have proven, debugged methods and options, we can only guess at the design possibilities. That we can texture the surface seems likely. We may be able to etch it, applying resists and sandblasting. We might be able to color, even grain glass
composites, by embedding colored glass fibers in either a random or “raked” pattern in a clear glass matrix.

Metal plate and sheet can easily be embossed, but perhaps only coarse pattern can be imparted to poured metal by mold forms. These uncertainties aside, the use of mold forms in habitat module fabrication and manufacture are a primary opportunity for textural choices with the goal being to use the resulting interior surface as decor in itself, not as a substrate for some hiding faux surface treatment.

Construction-processed surfaces might then subsequently have any mold imparted patterns or textures enhanced by several means.

- wall washer lighting can enhance textural shadow patterns
- colored bulbs or colored glass diffusers can wash textured surfaces with color tints.
- whitewashes based on lime (CaO) or Titanium Dioxide should soon be available to beat the concrete gray blahs.
- perhaps “stains” using metal oxide pigments might be used to highlight textural surfaces in directional patterns, depending on means of application

What we are talking about is principally the interior surfaces of the exterior pressure hull. In one-story modules, that includes the ceiling, which, if of concrete, may commonly be whitewashed.

Our point is that here is a method of instant "direct decor" in which the architect and purchaser have many options to choose from, simply by allowing the character (the "grain" as it were) of the chosen hull material to give an "encore performance." By choosing any of these direct decor options, the lunar habitat is finished and ready for occupancy much sooner. Then any sweat equity required or volunteered on the part of the frontier homesteader can be postponed, saved for other things and features to be added as time, energy, and funds are available.

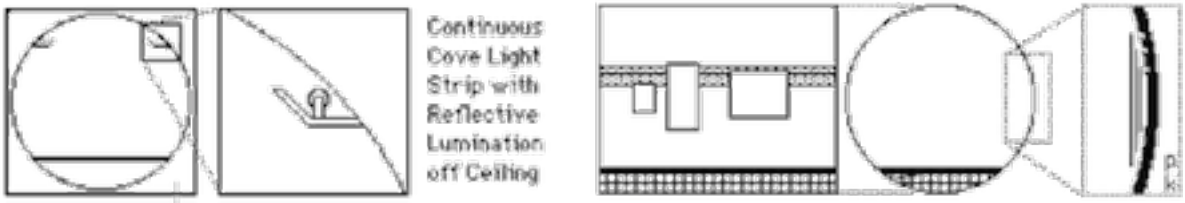
On the Moon we cannot afford to have housing units "under construction for months." The ideal ground-breaking to occupancy-ready interval should be much shorter, week at most, but with the ideal of "in one day" ever the target.

Construction in vacuum is a risk-involving activity and we want to do it in as manhour-light a manner as possible, reserving man-hour-intense activities for optional interior customizing at leisure.

Hull Details

"Trimwork" (akin to our "woodwork"), if any is desired on interior hull surfaces, can be of sheet metal, ceramic

tile, or glass composite, depending on the hull material (alloy, concrete, glass composite.) This trimwork can be of colors and shadings that blend in, compliment, or contrast with the substrate. Glass and ceramic glazes are made with metal oxide pigments, many or which are lunar-sourceable. Steel trim could be rust-finished or even stainless.



Built-in hanging grooves for on-the-wall items In addition to surface texture, pattern and detail,

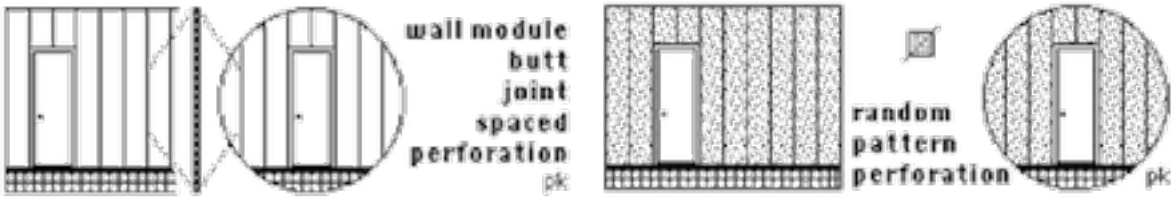
functional features can be built into exterior hulls, such as coves to hold ceiling wash lighting, chases for electrical wiring or conduit, and well-placed purchase points for hanging shelving, wall art, etc. The built-in features also serve to shorten the construction to occupancy interval. Even bench or banquette style seating can be provided as desired.

Interior Wall and Floor Stuffs

Interior walls and surfaces of interior ceilings (i.e.another floor above) are also likely to be manufactured,

fabricated, or constructed with materials that can provide an acceptable surface. Logical interior wall options are:

- modular half meter sections with steel frames covered with steel panels: finished through a controlled rusting process to introduce relief from gray monochromes, or of stainless steel. They can be variously textured or embossed
- custom built on site using steel studs and Duroc™ panels (a familiar item: half-inch thick fiber-glass-faced concrete sandwiches): the Duroc surface can be accepted as honest direct decor, possibly whitewashed, or stain-washed. Trimwork and/or wainscoting can be of ceramic tile.
- glass block walls - transparent, translucent, or opaque; of clear glass, frosted or sandblasted, or crude formula lunar glass of gray-black tones.
- steel framing "upholstered" with stretched fiberglass fabric over foil-faced fiberglass batting Interior walls too, even though made of harder materials than we are accustomed to using on Earth, can be pre-fitted with purchase points for hanging wall art and shelving. Consider this:



We wrote about wall options in MMM #76, June '94,np. 4. "Inside Mare Manor: Interior Walls."

Exposed Ductwork

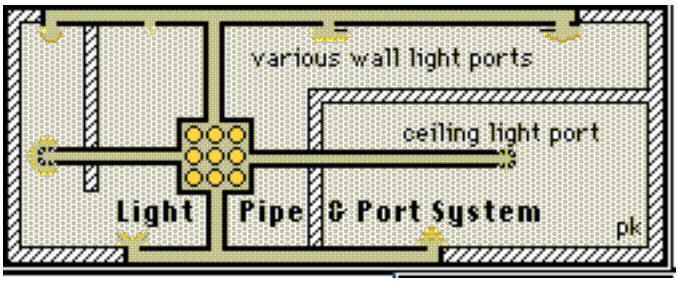
Another commonplace in urban Lofts are exposed ductwork for heating and air-conditioning. Using Systems to Decorate has become a flagship feature of the "industrial" style for many public buildings in the past two decades. Ductwork can be designed to have a simple comeliness of its own, adding interest, not ugliness. The

original motivator, of course, is the substantial cost savings of not having to "hide" such systems with false ceilings.

The same is often true of conduit carrying electricity throughout the loft or building. With a little forethought, the design of conduit and other "working" electrical and plumbing elements can be enhanced for eye appeal without compromising utility, and at nominal extra cost. Routing such systems offers another opportunity for input from the interior space designer. Slight changes of placement or routing cost little. All one needs to do is pay attention to the decor effects of various options - an attention that is not ordinarily given, but can be.

Light Pipes

On the Moon, where we have a chance to start fresh on many fronts, one significant opportunity to do things
differently is lighting. Light pipe technology has been advancing steadily. Light pipes are passive systems that deliver light efficiently from concentrated sources (solar concentrators, sulfur lamps, etc.) throughout interior spaces, in both straight runs and around corners, to places where the light is needed. Light ports in the pipe/duct system can then be decoratively enhanced by the choice of diffuser or lampshade analog. They can also be shuttered to "turn off the light.



"We reported on light pipes in MMM #66 p.7 June '93, "Let There Be Light: light delivery systems for lunar settlements need to be rethought", and on Sulfur Bulb technology in MMM #36 JUN 2000 p 3. "Nightspan Lighting: Sulfur Lamps & Light Pipes."

Flooring

Pressure Hulls have to have curved surfaces to avoid stress points along surface "intersections" that would be prone to fracture, and hence pressure loss. Thus for most hull designs, flat flooring has to be added later. So we will not discuss that here except to mention some of the obvious choices: cast basalt tiles, ceramic tile, glass-composite sheets, concrete pavers, and embossed steel sheeting.

A Frontier Primary Color Palette

The reliance on "direct decor" - letting the honest character of construction materials provide the setting for
added furniture, furnishings, and accessories will result in a naturally lunar, frontier palette of hues, shades, and tones to be played to in monochrome, complementary, or opposite suites.

Concrete gray tones can be easily "tinted" by washing them with colored light (bulbs, diffusers, etc.). Eventually, as locally produced sodium silicate and metal oxide pigment powders are produced, applied color "washes" may become an option. Lime or titanium dioxide "whitewash" will surely be the first of these to appear and become popular, on walls and ceilings alike. Metal oxide pigment stains might be used to give highlights to the texture relief.

Tile "trimwork" can accent the concrete, with glaze colors that play to or enhance the natural lunar grays. Steel and aluminum silvers, rust-cured steels or rust-cured steel trimwork can also add accent. Enamels for steels may not come soon.

Natural raw frontier glass will be of variegated moontones ranging from blacker to lighter. If regolith is routinely sifted for glass spherules which are then automatically sorted for color, crude glass with orange and green tones should soon be available.

Mirrors hung on moontone walls can also capture and "import" the brighter colors of added furnishings. Lamp

shades, ceramic glazed items, art glass, and, of course, abundant foliage and flowers can add all the "pop and punch" colors one could want. The "industrial" "loft-like" host decor of lunar frontier habitat modules need not be drab. The great creativity and amazing variety of ways in which our urban loft dwellers make spaces with industrial histories very homelike gives us not only insight into the future of lunar frontier homes, but confidence.

It's a wrap ! - of course, those who can afford it will find it chic, appropriately pretentious, to bury the construction processed surfaces with faux facade treatments of one sort or another. But our purpose here is to show what an "everyman's frontier decor" might be like. **<MMM>**

MMM #147 - AUGUST 2001

URBAN LOFTS & SETTLEMENT STYLE

Part II: More Clues from Loft-Living Styles

By Peter Kokh

In the MMM #136, JUN '01 issue, we tried to sketch out what the "feel" of lunar settlement interiors might be like, taking pages from the urban frontier's "Loft" decorating trends. Loft styles have been called "industrial" and that is fitting considering the origin of loft spaces - former factories and warehouses. But that origin is really incidental and does not get at the essence of the style, which I would prefer to call "direct decor" -- accepting the surfaces of construction materials (e.g. brick, concrete, steel, ductwork, etc.) as they are, not as a substrate for adding layered faux (false) surfaces such as plaster or drywall (sheet rock in some parts of the country) or paneling for walls and ceilings.

In a Lunar, or Martian, frontier setting, use of "direct decor" would allow faster occupancy, and showcase native materials instead of let's-pretend-we're-still-on-Earth "secondary" surfacing. Thus in addition to having modular habitats ready to occupy much faster, this type of transplanted loft style will go a long way to create unique and genuine Lunar and Martian home decors. But we have not exhausted the list of "Lofty Ideas" worth transplanting.

Open Floor Plans for Common Spaces In the prior article, we suggested a number of ways interior walls could be built to be direct-decor friendly. At the same time, it would be beneficial to pioneers eager to occupy their homesteads quickly, if the amount of interior wall structures needing to be built was kept to a minimum. Of course, such walls could always be added -- and moved -- later as desired with evolving life styles and family needs.

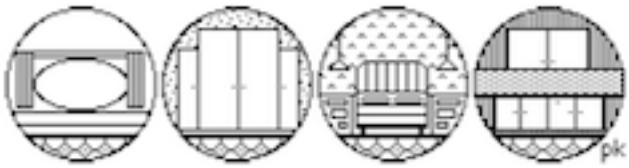
Urban Lofts commonly preserve as much of the "wide open spaces" feeling of their host shell as possible. Interior walls, often not extended up to the ceiling, are provided only where privacy is needed, and then commonly only to interrupt sight lines rather than to provide complete enclosure -- for bathrooms and bedrooms. To be sure, "great rooms," "keeping rooms," and other open floor plans for "commons" areas of the home are also growing in popularity in conventional new home construction and also in older home remodeling.

The open plan fits today's life styles. Yet many "compartmentalized" older homes, such as my own, have floor plans that resist being "opened up." They serve well enough, however.

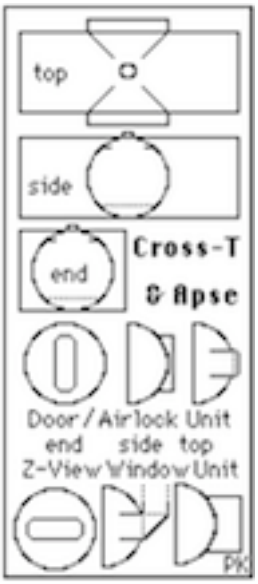
On the lunar and Martian frontiers, homestead construction is likely to consist of various assemblies of pre-manufactured modules. In MMM #75, May '94, pp. 4-6 "Lunar AppropriateModular Architecture" we showed how a "language" of only a few basic module types would permit quite a variety of "expression."

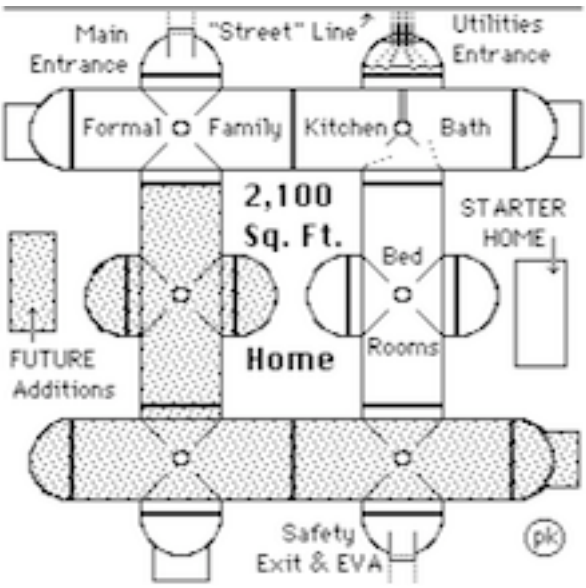
Use of modules provides spaces that have identities, even if the passage from one to the other is unrestricted. Such an architecture allows interflowing common spaces easy to individually dedicate to special uses: kitchen, dining, family, library, garden atrium, etc. It also minimizes linear footage of privacy walls needed for bedrooms and baths.

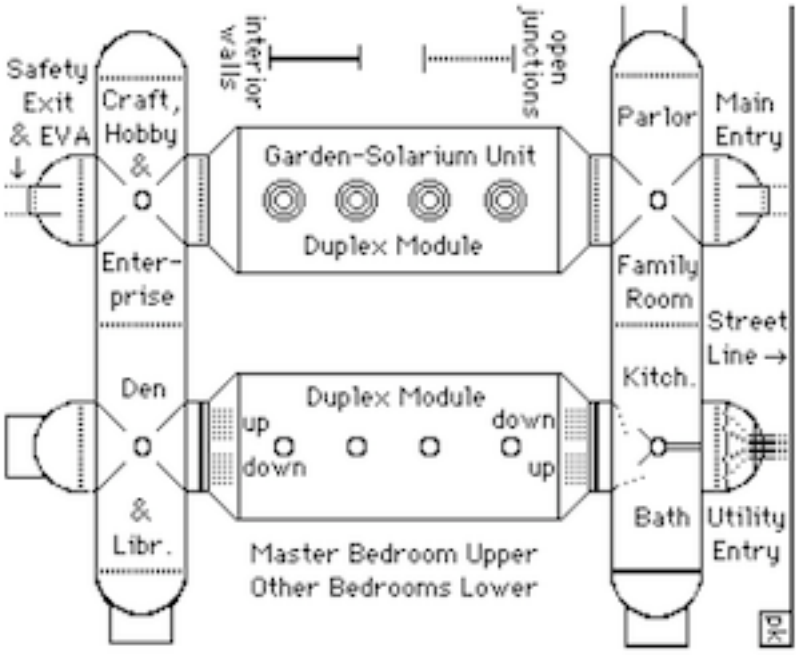
Below are some illustrations from that issue altered to show which module seams are open, and which are fitted with walls and doorways. Again, the layout options are endless -- these illustrations are meant to give the reader a general idea only.



Some of many "End Cap" Options: Picture Window; Closet; Bed head board; Kitchenette







As is clear from the floor plan samples above, the space within each of the interconnected modules is already

"distinctive" by its shape, how it meets or intersects with adjoining modules, and possibly by customer-chosen mold impression texturing. Each of these is a bonus not all terrestrial urban lofts offer. With this built-in distinctiveness, it is easier to give each space its own ambiance and personality.

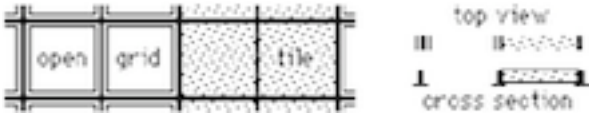
1. Distinctive Flooring: While pioneers can elect not to build interior walls where privacy is not an issue, they cannot elect not to add flooring unless they wish to confine their walking to a narrow strip along the bottom. This is so

because pressurized modules in the full or near vacuum environments of the Moon and Mars must be either spherical,

cylindrical, or toroidal to avoid critical level stresses on their structures from interior air pressure. Thus they "come with" curved bottoms. We must add flat flooring. A framing platform of metal alloy or glass composite members must be installed, in which can be set tiles, slabs, or other types of floor panels.

The choice of metal alloy panels restricts the amount of decorative freedom somewhat. Different surface textures can be used, along with contrasting color (i.e. a different metal alloy) "inlay" borders or stripes might be possible.

We wrote about using cast basalt tiles, especially wear and abrasion-resistant, for flooring in MMM #135 MAY '00, pp. 7-9 "Cast Basalt: industry perfect for a startup outpost."



Cast basalt tiles are self-glazed -- there is no opportunity to "add" color by glazing. However, there may be room to vary the shading of gray-tones by choice of basalt feed stocks. That color range will be very subtle at best. Perhaps the best option here is to impose distinctive surface textures by varying the mold shapes. One could also vary the size and shape of cast basalt tiles and create patterns in that way.

Once we start producing metal oxides for use in producing better alloys, we will be able to use many of those

same oxides as colorants for stained glass and ceramic glazes. That will open a wide range of decorative possibilities.

Panels made of glass composites can be made in various "moontones" by varying the mix from which the matrix glass is formed. Once we are able to cast clear or transparent matrix glass, then we could add color by using metal oxide powders to dope the glass batches used for making the glass fibers that give the composite its strength. Then we might also play around with combing or otherwise arranging the glass fibers in the matrix to give distinctive "grain" or other patterns to the composite. Nothing like this has yet been tried as glass composite research has been stuck in the lab, totally ignoring a potentially tremendous Earthside market for products like boat hulls, architectural elements, and high end case goods furniture items (where appearance, not price, is important.) We wrote about that line of terrestrial R&D inMMM #16, JUN '88 "Glass Glass Composites."

2. Arrangement of Furniture & Furnishings: even if we pass on the opportunity to create extra distinctiveness of continuous areas by playing with flooring options, we can easily create distinctive "room settings" by simply clustering furniture and furnishings into cozy groupings. Creating a focal point for each setting will help. We are used to doing this here on Earth. Focal points can be a picture window, a fireplace, a catch-your-eye painting or sculpture, or a beautiful area rug. In time, Lunan pioneers will create enough home grown options to do likewise. If there is a generous "heirloom allowance," allowing each settler to bring along one personally special item from Earth within certain reasonable weight and volume restrictions, then a painting, a rug, or as piece of sculpture from "Old Earth" could be used for such "focal points."

3. Using Accent Colors: On Earth, many homemakers in recent decades have chosen to go with neutral or monochrome color schemes. Some even go so far as to profess a certain "superiority" for such choices. That is a very

euphemistic way of diverting attention from their fear of being able to handle color in a non-gaudy way. We humans see in a full range of colors, and enjoy them. Not to play to that pleasure within our homes is a personal self-inhibiting choice but hardly a mark of higher culture.

On the Moon and Mars, where the exterior landscapes are so extremely monochromatic to begin with, almost

everyone will feel the need to use abundant colors indoors, especially those not to be found out on the surface. Pioneers will cultivate their green thumbs to an extent unusual on Earth. With no life at all outdoors, abundant green foliage and flowers will be welcome and pursued with dedication.

Other coloration options will come slowly as we learn to extract specific elements and element combinations from the regolith. On the Moon, true white (calcium oxide = lime, aluminum oxide, titanium dioxide) and true black (ferrous oxide, manganese dioxide) will help "bookend" the gray-tones with classic emphasis.

Among the first real "colors" will be ferric iron oxide or "rust". Sulfur provides a pale yellow, chromium oxide a
green. The holy grail will be the isolation of cobalt: cobaltous aluminate produces the brilliant "cobalt blue." These oxides can be mixed to produce in between colors and shades. There seems to be no lunar-sourceable inorganic source of either brilliant yellow or true red. We'll have to satisfy our appetite for these colors with flowers, and maybe birds. See also MMM #63 MAR '93, pp. 10-11 "Color the Moon anything but Gray."

Once such colorants are available, they can be worked into the decor scheme as stained or art glass (including lamp shades or light diffusers), fiberglass fabrics, ceramic objects, "regolith impressionism" paintings, and other ways. Giving each "room setting" a different accent color or suite of accent colors will help create special areas.

4. **Dividers:** on Earth we frequently resort to "room dividers" to subdivide large rooms or create special settings in great rooms and lofts. Dividers can be made of anything, and be either freestanding or suspended from the ceiling.

One attractive option for use on the Moon especially is suspended carpets. Carpets, and fabrics in general, are very useful for acoustic sound deadening. The problem on the Moon is twofold: first it would be prohibitive to produce carpets (or other fabrics other than for clothing or towels) from the usual organic or synthetic organic fibers. That pretty much leaves us with glass fibers. We have been producing fiberglass draperies for years and they work well for one reason: very little wear and tear. We do not walk on them or sit on them. Fiberglass is not very wear resistant. Happily, on the Moon with its light gravity, the natural cushioning of our feet and buttocks may be enough. We can still make fiberglass carpets, possibly of unlimited color and design options, if we put them on walls or if we suspend them from ceilings. Carpet dividers will be a great way to subdivide inter-module common spaces.

5. **Accent & Mood Lighting:** Another way to create "room-like" settings in larger open spaces is with controlled, discriminate lighting. In the past, one often had only one choice: ceiling light fixture or table/floor lamp -- each at one set level. The introduction of three-way lamp bulbs, then of dimmers created many more options. Today with all new light bulbs (especially, halogens and folded fluorescents) and new recessed lighting options, the possibilities for controlled accent and mood lighting are endless.

It is too early to say which light bulb types are best suited for local manufacture on the Moon. One option is to keep light sources, and the heat they produce, on the surface and use fiber optics and light pipes to deliver light where needed in homestead interiors. Movable shutters can throttle the amount of light delivered to any one spot. Working in special diffusers will multiply the special lighting effects available. Shades can be made of glass, ceramic, and punctured sheet metal. Light diffusers of stained glass can lend color to the whole surrounding area.

Take two identical pioneer homesteads: same floor plan, same furniture, same furnishings. Give one only full-on high level general lighting. Install full control lighting in the other so that one room can be fully lit, another have just task light by an easy chair for reading, other areas just enough light to find one's way without stumbling. In the first, the colors are fixed. In the second, you can alter the colors to suit your mode just by switching colored diffusers. Obviously if it is a comfortable home that we want (and we need to prevent gross defections back to Earth,) providing a full range of lighting options is important, not just to defining interior spaces but to the level of comfort and satisfaction.

Open Shelving

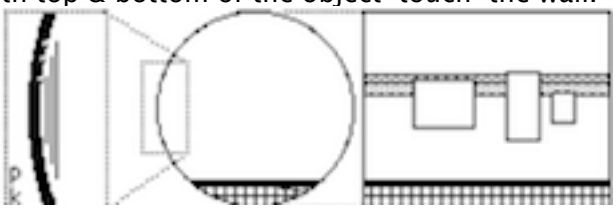
Another choice one sees in some Lofts -- it is by no means common, however -- is to scratch the high expense of wall cabinets for kitchens and other areas by using open shelving systems, which can be built in a number of ways. Doing so involves a deliberate choice to let the shelf contents provide decoration.

In kitchens this is relatively easy if one has tableware and utensils worth showcasing. One can choose to do this elsewhere as well, in bedrooms and bathrooms for example. Here, if decoration is a

goal as well as simple storage, one can either sort items by color (sweaters, towels, blankets, etc.) or arrange sundry items into pleasing “vignettes.”

In MMM #76 JUN ‘94 p.8 “On the Wall” we described ways in which the curved walls of habitat modules could be designed to make shelving easy.

On the horizontally concave outer walls of cylinder modules, only the central portion is suitable to hold things flat so that both top & bottom of the object ‘touch’ the wall.



A series of built in hanging strip grooves is a solution that may work, and even presents decorative possibilities, i.e. as broad horizontal striping. Objects can be hung anywhere along the length of the wall, utilizing the hanging groove that best suits their individual height. While the result may be that pictures and other objects are hung slightly below the customary “eye-level”, the hanging grove stripe, perhaps differentiated by texture and/or color from the rest of the wall, will be at the top of this range, serving as a visual corrective of sorts.

Shelving is cheaper and easier to provide than furniture-quality cabinetry. So this is yet another “Lofty Idea” with appeal to frontier pioneers. <**MMM**>

MMM #154 - APRIL 2002

HOMESTEAD AMBIENCE: WATERFALLS & FOUNTAINS

Therapeutic Indoor Recycling Water Features

By Peter Kokh

Thanks to strong marketing by suppliers for garden pools and water features, both indoor and outdoor, these

delights are finding their way into more and more gardens and homes each year. One can buy fully assembled predesigned units in a bewildering array of sizes and styles, or buy key parts and create one’s own. Imagination, not cost, is the only limit. Indoor “water features” would seem to be just what the doctor ordered to make lunar homesteads inviting retreats.

The reasons are that they:

- use only recirculating water reserves
- require only lightweight imported pumps, hoses
- can use basins made of many lunar materials
- are an opportunity to “domesticate” moon rocks
- are an ideal setting for plants
- can be combined with fish ponds
- offer several ways to add color
- provide a treat for four of the five senses

Recirculating Water

The water used in these water features recirculates over and over. One must make up for evaporation, of course, but evaporated water is not lost to the biosphere as it can be recovered by dehumidifiers. It is essential that the outpost or settlement have more than marginal reserves of water as a matter of safety and security. But why not put such reserves "to work" in ways that improve overall morale? (see MMM #67, July '93, p. 6. "Reservoirs")

Imported Pumps

These water features use small pumps that are relatively light weight, plus hoses and clamps. It can be argued that the intangible benefits of having water features in homes, home gardens, and public common spaces is

great enough to justify their import -- after all, the vast bulk of the weight (basin, water, and sundry adornments) can all be made locally.

Made on Luna Basins

Basins, pools and step pools need to be impervious to water and are commonly made of inorganic materials. On the Moon we can make such items from glassified regolith, glass composite, cast basalt, various metal alloys, glass-sulfur composites, and concrete. The choices are quite wide and will support a wide variety of sizes and variation in design.

Incorporating Moonrocks

Water feature designers often incorporate rocks in their creations. After all, in nature, rocks are invariably associated with waterfalls and rapids. We won't find "river rock" anywhere on the Moon, of course, but we should be able to make interesting arrangements using larger moonrocks and breccia. As an alternative, we could "make" rocks by casting basalt or concrete in various shapes. In the first path, we find one more way to "domesticate" moon-rocks and thereby make the surface that much less alien to the eye.

Working in Foliage

Again, in Nature, foliage is commonly more dense and rich in proximity to water. We can make our house plants look more natural clustered around a water feature. With a little ingenuity and extra plumbing, we might even train the water feature to meet the watering needs of the plants.

Integrating Fish Ponds

In larger size fountain pools and waterfall basins, we can raise a variety of common aquarium fish species. Fish add surplus motion and color, and reinforce bonds with nature that would weaken if we had only plants

to enjoy.

Avenues for Color

Integrating a water feature into the home or home garden, provides several opportunities to add extra color for the eye to feast upon: moon rocks in direct contact with water or even just splashes of water, may tend to take on rusty patinas, to the extent of their iron content. Rust will be a warm tone that will provide welcome contrast to background gray tones of structural concrete, cast basalt, glass composite, or metal. the many greens of foliage. Plants go well with rust tones, by the way. Think terra cotta pots! flowers and blossoms colorful fish

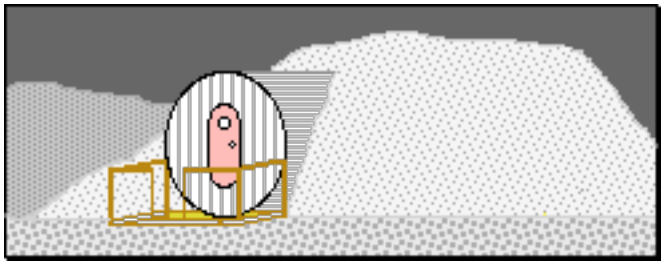
Treats for Four of the Five Senses

The reader is welcome to try to identify ways in which water features provide a taste treat for the tongue. We didn't try. As to the other four senses:

- Eyes: The designs and shapes of fountains and waterfalls can be designed are limited only by the imagination. They can be rustic or crisply geometric, incorporating many textures. Amateur-friendly, they are also inviting to artists as well. Spot lighting can be used and/or underwater lighting. Plus colors!
- **Ears:** Soothing "white noise" that varies with flow and design.
- **Nose:** That fresh "after-the-rain" smell in the air.
- **Touch:** Textures of the different surfaces can vary from ultra smooth to quite coarse or even sharp. A randomizer added in to the ventilation system, could waft gentle fresh breezes around the surroundings.

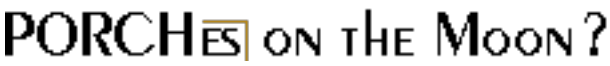
Settlers need ample morale boosting perks. Water features will be among them. <**MMM**>

MMM #157 - AUGUST 2002



Personalized Porches on the Moon?

The very idea of a lunar habitat having a "porch" seems absurd at first thought. But on Earth, porches serve a
number of useful functions, and we examine the question from this viewpoint -- how could we serve these functions for lunar pioneers? The whimsical sketch at right is not quite an illustration of the applications we foresee. ==> below



PORCHES ON THE MOON

Personalization of Habitat Entrances

By Peter Kokh

The Inspiration for this essay was a recent 7-28-02 HGTV Cable TV special "Americans & Their Porches"

Porch: 1. an exterior appendage to a residence, forming a covered approach to a doorway.
2. U.S. a verandah.

A brief ancient/modern history of porches

The porch or portico is an ancient amenity going back at least two thousand years. Porches became a common feature of homes built in the 19th Century in America, offering a middle ground between the inner sanctum of the home itself and the outside world, specifically the neighborhood beyond. They have served several functions:

- Greeting neighbors and passersby without having to invite them inside, thus enjoying the pleasures of civility and neighborliness
- Enjoying the weather within reach of shelter; sunrises and sunsets, approaching storms, breezes
- Nature watching: sunrises and sunsets, trees and gardens, birds and other wildlife
- Storing paraphernalia used outdoors
- Shedding dust and mud before entering the home

Porches began to disappear from both new and old construction after World War II. New housing was needed at the lowest no-frills price possible. In old housing, porches were converted to extra indoor rooms (bedrooms, 3-season rooms) for growing families more cheaply than by building an addition from scratch. Television was new and proved to be an addictive lure away from porch-sitting (people in general seemed to become more self-involved.) Air conditioning made indoor relaxation more appealing.

Small town America was not immune to these changes, but seemed to hold on to porches longer. The pendulum is swinging back. Boredom with the TV/Cable boob tube passive wasteland, a purposeful reemergence of neighborliness, a rediscovery of the pleasures of relaxation and real weather -- all these are luring more people to their own bit of outdoors. There is a growing "new urbanism" that is rediscovering the city (as opposed to the suburbs) and the greater opportunities afforded by higher density and diversity to enjoy the pleasures of more frequent contact with neighbors. Porches build community.

Functions of Porch Analogs on the Moon

The essence of a porch is an interface between "home/habitat" and "world." On the MooN, in pioneer settlements, the opportunity to establish such an interface occurs on three levels:

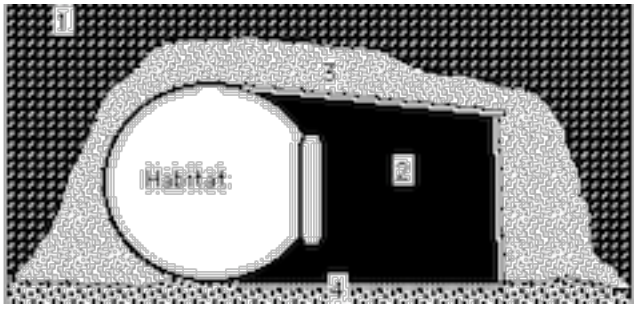
1. Outside the airlock (if there is one)
2. Outside a door opening onto a pressurized public passage
3. Inside adjacent to an indoor "yard" or solarium garden space or "Earthpatch"

Out-vac "Porches"

Our illustration above may seem whimsical. But when you think about it, an airlock-connected "porch" could be useful:

- provide a place and the means (a special "doormat") to shed troublesome moondust before entering - we talked about ways to do this in MMM #89 OCT '95, pp. 5-6 "Dust Control" (design of a special turtle-back suit and mated airlock)
- A place to store equipment used outside
- If roofed, shade from the glare of the sun
- Relief (if the roof-canopy has a sufficient regolith blanket) from micrometeorite rain and cosmic ray exposure while doing routine outdoor chores like changing out fuel tanks -this is the concept of the "Ramada" which we talked about in MMM #37. JUL '90 pp. 3-4 and in MMM # 89, OCT '95 pp. 3-4 "Shelter on the Moon"
- An opportunity if so desired, to customize the out-vac entry to their personal family haven

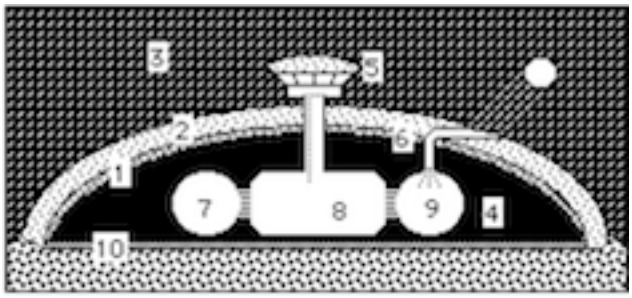
Here is an illustration of the porch canopy concept from the MMM #89 "Shelter" article:



Directly Shielded Habitat with Carport/Service Area Shed:

KEY: (1) Exposed Vacuum; (2) Sheltered Vacuum; (4) Compacted and sintered floor of carport, part of dust control strategy. Another way to achieve the same sort of protection is to place habitat structures within or under a shielded hangerlike shed.

Another illustration from the same article:



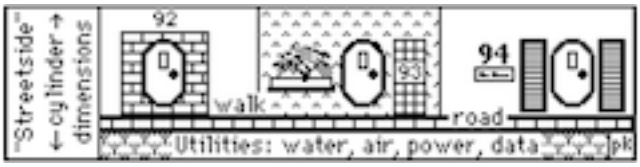
KEY: (1) Space Frame Arch, Fabric Cover; (2) 20 cm or more regolith dust shielding; (3) exposed vacuum, radiation, micro-meteorites, UV, solar flares; (4) protected lee vacuum service area; (5) observation cupola with ladder shaft to habitat space below (6, 7, 8, 9); broken-path solar access via heliostat and fresnel lens diffuser; (10) compacted, sintered hangar apron

Ways to customize out-vac surface entrance (color, texture; design options) were discussed in MMM #55 MAY '92, "Moon Roofs." [reprinted in MMMC #6]

Middoor Porches

The concept of the "middoors" is simple. In lunar settlements, there will be pressurized climate-controlled shielded spaces "outside" individual habitats and work structures but "inside" as opposed to the vacuum and radiation-washed exterior surface "out-vac." Recently, we wrote about the role of these middoor spaces in supporting a large portion of the settlement biosphere: MMM #152 FEB '02, pp. 5-6.

In this concept of the modular settlement, growing naturally a module at a time, each residence unit has an airlockable entrance on to a pressurized residential thoroughfare.The street frontage serves as the interface through which individual-private and shared-public worlds meet. Thus that entrance façade will probably be a more popular canvas for a distinctive statement. "I'm unique and proud of it." Here is an illustration of some possibilities from MMM # 109, OCT '97 pp. 3-11 "Luna City Streets." [reprinted in MMMC #11]



Sidewall section of a residential street, suggesting how home dwellers might customize entrance façades. Ibid. p. 6 Now these "middoor" entrances provide an architectural opportunity to do more - to provide a "porch" enabling setback or easement on the residential street. These can be left empty or unstructured, but may eventually entice home dwellers to use them as semiprivate, semipublic spaces where they can relax and enjoy opportunities to socialize with their neighbors and passersby. Such a "porch" will also allow them to enjoy the less controlled middoor climate -- in the middoors, temperatures might be allowed to swing in natural dayspan-nightspan (29.5 day) cycles as well as seasonal cycles fitting for the kinds of plants (and wildlife) desired. It will also provide "at home" relaxation space from which to enjoy any settlement "urban wildlife": birds, butterflies, squirrels, etc.

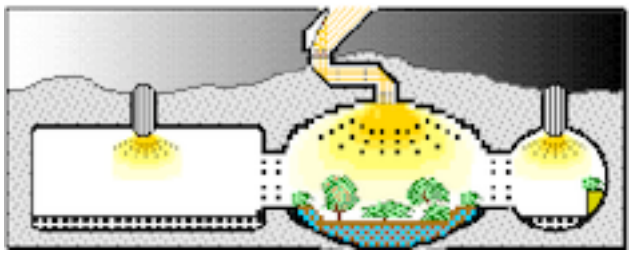
The Middoor porch would probably not have a roof or canopy, sharing the protection of the unpressurized street itself. But railings, hanging pots and planters, swings and gliders and other seating and tables might become a common sight.

The pioneers will have other opportunities to socialize and bond, to be sure: at school, at work, and in voluntary group activities. But there is something special about the unprogrammed unstructured opportunities for "neighborliness" that a "curbside" porch brings. It is an easy place to be, within reach of one's inner sanctum on a moment's notice or whim. An "at home" place to enjoy living in a settlement.

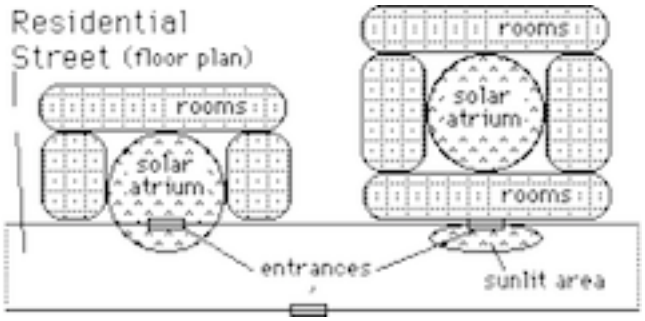
It is not enough to build the settlement physically, nor enough to provide an ample and varied modular biosphere. It will be essential, if a human presence on the Moon is to truly endure and not be just another false start leading to history's most expensive "ghost town" to aim beyond those two goals. We have to do what it takes to build the settlement as a community . The "middoor porch" may have a strong supporting role to play in this effort.

Solarium Garden Patios

One of the noted pleasures of porch-sitting, enjoying the surrounding trees, shrubs, and flowers, to be sure does not require street-facing placement. A backyard patio will do as well. On the Moon, homesteads are more likely to "interiorize" any private "yards," that is, to have garden space or "Earth-patch" atrium solaria in which they can garden away to their hearts' content. See MMM #148 OCT '01 pp. 3-6.



If you have such a pleasant space within your home, full of greenery, flowers, fresh air, fragrances, and sunlight, why not have a place along its perimeter to sit and relax and commune? It is not a matter of choosing to have a curbside porch and an interior atrium patio -- lunar homesteaders can have both. But depending on the architecture, they could have both in one. In other words, put the atrium solarium to the front of the house so it opens onto the streetscape as well. The MMM #89 article illustration shows the both options.



Strange as it sounds at first, the “porch” may become a a commonplace of lunar pioneer life. <**MMM**>

Cobalt Blue & Other Substances From Lunar Regolith

By David A. Dietzler

Prospector Pete [Peter Kokh] has described the manufacture and use of paints made with metallic salts dissolved in sodium silicate. Only materials available on the Moon are used. Here is a process, which is by no means the last word, for getting necessary substances from lunar regolith.

1) Roast regolith to drive out H, N, CO, CO2 (carbon will react with oxides), S, He 3, He 4, Ne (and all other noble gases). Separate volatiles thru fractional liquefaction. There are also traces of fluorine (140 ppm), chlorine (14 ppm), bromine (0.1 ppm), and iodine (0.0006-1.4 ppm) in the regolith, but they are probably in the form of salts that could be leached out of the regolith with carefully recycled water. Calcium fluoride is not soluble in water and these halogens may be bound in silicates, so leaching with water may not be useful. Barium at 200 ppm is present in the regolith most probably in oxide form. Barium oxide is soluble in water, unlike most oxides. It reacts with water to for barium hydroxide. The simplicity of water leaching is appealing.

2) Use electromagnets to separate ilmenite grains (FeTiO), iron, iron oxides, cobalt oxides (Co 25 ppm), nickel oxides (Ni 200 ppm), troilite (FeS) from roasted regolith. Reduce with heat and hydrogen to yield water and hydrogen sulphide gas. Electrolyze water to recover hydrogen and store oxygen. Hydrogen sulphide is either electrolyzed or pyrolized to recover hydrogen and get sulfur. Heat the metals with carbon monoxide to produce carbonyls of iron, cobalt and nickel that can be formed and decomposed at different temperatures to get the pure metals.

This is called the Mond Process. Iron composes about 14% of the regolith and will form iron pentacarbonyl (Fe(CO)5). This boils at 103 C. and decomposes at 200 C. Nickel tetracarbonyl (Ni(CO)4) boils at 43 C. and explodes at 60 C. Caution will be required when decomposing small amounts of this substance at a time. Cobalt tetracarbonyl (Co2(CO)8) melts at 51 C. and decomposes above this temperature. If the mixture is heated high enough to distill the iron and nickel, the cobalt carbonyl will decompose.

To separate the cobalt and titania residue that will be leftover, the mixture could be roasted with carbon monoxide again to reform cobalt tetracarbonyl. Since this is soluble in alcohol, ether and carbon disulphide, it will be easily washed out of the mixture then heated and decomposed to recover CO and obtain pure cobalt for our blue pigments. Titania will remain and this will be carbo-chlorinated and electrolyzed to get pure titanium and oxygen.

Carbon for CO will be imported and traces of carbon extracted from regolith will be used to replenish losses due to leakage. Organic solvents will be handled in a similar manner. Now, all we need is some sodium and silicon oxides to get sodium silicate to make paint. Sodium hydroxide heated under pressure with silicon dioxide will produce sodium silicate. Sodium hydroxide is made by electrolyzing aqueous solutions of sodium chloride in chlor-alkali membrane cells. Hydrogen and chlorine will be imported, recycled and traces from the regolith used to replenish leakage losses. We will also need aluminum to make cobaltous aluminate (Co(AlO2)2) for our beautiful blue paint.

3) Take the roasted and magnetically beneficiated regolith and leach it with hydrofluoric acid. This will produce water and silicon tetrafluoride gas that will be boiled off (some UF6 also, perhaps). That water will be electrolyzed to recover hydrogen, the oxygen stored for many purposes and the SiF4 will be decomposed at high temperatures to get pure silicon which composes 20% of the regolith and re-

cover fluorine. This will leave a pile of fluoride salts behind. These will be heated with silicon (silicothermic reduction) to make more SiF4 gas that will be decomposed for recycling. Since the SiF4 will evaporate from the mass, the reaction will be driven strongly to the right. Equilibrium won't stop us!
4XFl + Si = 4X + SiF4

4) Now we have a granulated (hopefully) mass of free metals that must be separated. Zinc is refined by distillation because of its low boiling point of 907 degrees Celsius. There's only about 15 ppm zinc in regolith, but we want to get it. Although most of our magnesium alloys will be made with aluminum, silicon, thorium and manganese; we might want some zinc for some magnesium alloys and other special purposes including plant nutrition. We will roast this mass of metals in a solar or electric furnace to boil off and distill sodium (3300 ppm), potassium, phosphorus, any remaining sulfur, cadmium, selenium, arsenic, rubidium, cesium, mercury and zinc.

All of these boil at lower temperatures than zinc. Some are present only in traces. Mercury is almost nonexistent at 0.0006-0.013 ppm, meaning we'll only get a few hundred grams to a few kilos from a million tons of regolith, but how much mercury will we need? We will acquire substantial quantities of sodium to make sodium silicate for paints. We will also have some potassium to make potassium silicate which might also be of use. We will have silicon for PV cells and roast it with oxygen to make pure silica for glass and making sodium silicate.

5) Now we need aluminum to make cobaltous aluminate. Various chemical processes will be used to separate the remaining metals: aluminum, magnesium, calcium, manganese, chromium and trace metals including copper (11 ppm). Sulfuric acid leaching, electrolysis, electrostatic separation similar to the action of a mass spectrometer, and other methods will be applied. Much has been written about this by O'Neill and company. The CD-ROM in the 3rd edition of The High Frontier may be consulted. It may also be possible to heat this mixture with carbon monoxide to produce chrominum hexacarbonyl (Cr(CO)6) and manganese carbonyl (Mn2(CO)10). Manganese carbonyl melts at 154 C. but begins to decompose at only 110 C. Fortunately it is soluble in most organic solvents. Chromium hexa-carbonyl is not soluble in alcohol, ether or acetic acid; so one of these will be used to draw off the manganese carbonyl and leave the chromium carbonyl behind

The manganese bearing solution will be distilled, the organic solvent recycled and the carbonyl decomposed with heat to get manganese and recover CO. The chromium carbonyl melts at 150 C. and explodes at 210 C. This could be a problem. It is slightly soluble in iodoform and carbon tetrachloride. Multiple extractions with these solvents after the manganese carbonyl is removed will be performed to get the chromium out of the Al, Mg, Ca, and trace metals mixture.

Organic solvents may be boiled off and distilled at lower temperatures by taking advantage of the free vacuum of space. Chromium carbonyl decomposes when solutions are exposed to light. Photochemical decomposition may be less violent than heat decomposition to get the chromium. Other transition metals like vanadium, niobium, tantalum, molybdenum, tungsten, rhenium, ruthenium, osmium, rhodium and iridium; traces of which some of these are found in lunar regolith, also form carbonyls that may be extracted.

The Al, Mg, Ca and trace element rich residue could be mixed into molten sodium hydroxide. Magnesium will float on top and be skimmed off. Aluminum will dissolve into the alkali which can be poured off and boiled down. Alumina rather than pure aluminum will probably remain due to reaction of aluminum with sodium hydroxide and this can be purified with the Alcoa process. Calcium and traces of other metals will remain to be purified by various processes. Cobalt, alumina and sodium silicate for azure blue paint will be produced along with many other substances when this point is reached. <**DD**>

REFERENCES: The regolith elemental composition data in this paper was obtained from **The Lunar Rocks** by Brian Mason and William G. Melson, Wiley-Interscience, New York: 1970.

Chemical data obtained from **Hawley's Condensed Chemical Dictionary** 11th edition revised by N. Irving Sax and Richard J. Lewis, Sr. , Van Nostrand Reinhold Co., New York: 1987

The use of sodium hydroxide to extract magnesium and aluminum is described in the Artemis Data Book, "Sodium Hydroxide Method for Extracting Oxygen from Lunar Minerals" by Dr. Larry J. Friesen, 3/20/00, available:

www.asi.org/adb/02/02/03/sodium-hydroxide-method.htm

Sodium Silicate / Metal Oxide Paintings


Right:"Portrait" Megan Storrar **Left:** "Moon Garden #1" Peter Kokh

"Stereochromie" & the Prehistory of "Lunar" Waterglass Paints

By Gerald J. Grott <jgrott@cci-29palms.com

Email to KokhMMM@aol.com, September 16, 2001

Early applications of "Stereochromie"

The first recorded origin of painting with waterglass and inorganic pigments was about 1840. It was known as 'stereochromie' and most university libraries have one or more references under that name. Hundreds of buildings in middle Europe still sport external paintings in bright colors though they are over a century old. The shroud of Turin, scores of feet high, was painted on linen and hung in a German Cathedral until destroyed by Allied bombs in WWII.

I myself started with this about 50 years ago. My original purpose was to flame proof wood with bright colored paint that soaked in. It worked very well as, on exposure to high heat, the wood would char but not burn.

In the 1970's we started a new business to commercialize the matching of the natural colors of rocks, particularily "Desert Patina", so that rock surfaces exposed by earth moving and blasting can be economically restored to a permanent matching surface coloration. We purchased the sodium silicate in numbers of 55 gallon drums. Unfortunately, our young manager died of cancer and none of us chose to leave our own businesses to run that one and we let the business die.

Methods & Tricks of the Trade

For painting pictures and illustrations, most any of the truly insoluble inorganic pigments are compatible with sodium silicate. However,you must be very careful not to have any contamination with soluble carbonates or sulfates . These are in detergents and soaps so you must rinse surfaces carefully before painting.

Also, avoid painting on cloths that have sizing in the fabric. Sizing in new cloth will almost always cause flaking or other decrepitation of the silicate. As history shows, unsized linen is a good base.

Magnesium oxide is a good material for reacting slowly with sodium silicate to form a 'permanent' rock like

coating. I have several full sized notebooks of R&D regarding the use of sodium silicate base materials for sealing surfaces against moisture penetration and particularly for avoiding deterioration of marble objects or masonry of, or containing limestone or magnesite.

You (addressed tp Peter Kokh) are on a good course. I wish you good luck.

Jerry Grott

[Editor: I am grateful for Jerry's advice, but have yet to take time to try out his "tricks of the trade."- PK]
[Editor: note to the MMM Classic #16 reprint of this item. We were experimenting with sodium silicate based paint. Now Sodium and Potassium are closely related element, and it appears that Potassium Silicate paints , now being produced commercial as "all mineral, zero volatiles, paints" are fully stable and do not exhibit the deterioration over time of the bond with the substrate being painted. This is an option for lunan artists. We can't wait to try them out! 06-21-2007 - PK]

MMM #158 – SEPTEMBER 2002

A Versatile Lunar Material of Choice

By Peter Kokh

In case you haven't noticed, concrete "isn't just for sidewalks and driveways anymore." Concrete is being reinvented, brought "into the 21st Century" and reformulated for a whole host of new applications old concrete people had never thought of before.

Most of us have been aware of "shotcrete" for some time now. Shotcrete is a refined homogenized mixture strengthened by fiber additives so it can be pumped through a hose and sprayed on interior and exterior surfaces over attached steel mesh. Common applications are on the ceilings of lofts and industrial buildings and the inside of dome structures.

But now manufactures are using it for high end flooring, tile, shingles, textured wall panels, and more.

Concrete has these things going for it:

- it is poured at room temperatures (and below) and does not need high heat to fabricate as do glass, ceramic, and metal alloys
- it can be pigmented
- it can be stained and painted with many faux finishes to mimic other materials or with a unique character all its own
- it is an ideal for one of a kind and low quantity items and for outside the factory on site production.

Relevance for the Space Frontier:

Lunar Concrete Enterprises

These "selling points" make it an attractive material for frontier pioneer entrepreneurs catering to the Lunar and Martian homestead market, as well as to do-it-yourself inclined individual homestead owners. Future Lunans will have to show considerable resourcefulness in substituting for exotic (to them) materials commonplace on Earth: wood, plastics, other petroleum-based synthetic materials.

That making items for the homestead out of concrete does not require special factory furnaces or even small houseworthy kilns, as would on site manufacture of glass, ceramic, or metal alloy items, makes concrete an option that is sure to become a mainstay. Cured and used indoors, the water in the poured wet mix is recovered to the biosphere. It can be pigmented with metal oxide powders.

With all the new recently field-tested ways to play with concrete's surface appearance, one doesn't have to settle for plain concrete, as it can be made to mimic ceramic tile, terra cotta, even wood (in surface texture and color).

However, not all the new tricks being applied here on Earth promise to be applicable on the Moon!

Here are just some of what would seem to be "Moon-appropriate" applications:

- tables, table tops and countertops
- contour-shaped seating surfaces & benches
- lamp bases
- planters – big, small, inside, streetside

- sink basins
- shotcrete interior finishes
- textured wall panels
- floors and floor & wall tiles
- trimwork (analogous to “woodwork”)
- mantles & fireplace surrounds
- fountains & pools
- inside sculptures
- garden hardscapes
- “architectural” elements
- streetside entry trim
- streetscape sculptures
- embrasures (hold back shielding surrounding an airlock access)
- air lock entry trim
- shielding mound decorative cladding
- out-vac sculptures

Some of these items are likely to be mass produced, others custom ordered or even custom made by entrepreneurs in a shop or on site, and by do-it-yourselfers, for themselves, or as part of a “cottage industry” enterprise startup. This wide range of applications and appropriate fabrication situations makes concrete so versatile.

The Devil is in the Details

Many of the new applications for concrete involve products made by extrusion. This requires a very smooth and homogeneous mixture with considerable strength. That strength is achieved by a high fiber content. Now on the Moon, it should be no problem to manufacture both glass and steel fibers. Relying on them alone will not produce the higher qualities of the cement formulations now being widely used. For in almost all cases, here the glass fibers are jacketed with polypropylene, a petroleum-derived material that will surely fall in the exotic category on the Moon. Further, these glass/PP composite fibers are complemented by PVA polyvinyl alcohol fibers, another Moon-exotic material.

[**New tests** show that glass fibers produced in vacuum have some elasticity. This may solve the perceived problem.]

In addition to this fiber content, most extrudable concrete mixes substitute “Illinois Fly Ash” for up to 70% of the cement. Cement is a calcium based material that will be fairly easy to produce in large quantities on the Moon. As for the ash, a substitute that comes to mind is the fine powdery component of regolith, likely to be sifted out (and thus available as a homogenized byproduct) of most lunar regolith processing operations.

However, particle grain-size isn’t the only thing that matters. Particle shape comes into play as well. While the irregular jagged shape of lunar “fines” gave the lunar simulated concrete prepared by Dr. T.D. Lin in the 1980s great strength, “twice that of everyday terrestrial concrete,” that very same asset becomes a liability when it comes to extrusion of the liquid concrete mix. Illinois Fly Ash (IFA) has a spherical particle shape that makes it slippery, much like graphite powder. It should be possible, however, to further separate the lunar regolith fines for their high glassy spherule component. These spherules have been produced by the high extremely concentrated heat of impact in eons of constant micrometeorite bombardment.

But what about the fly ash chemical character - the regolith fines and glassy spherule inclusions should both be rather inert. According to the Fly Ash Resource Center

[www.geocities.com/CapeCanaveral/Launchpad/2095/flyash.html]

Fly ash is “the finely-divided CCB [coal combustion byproduct] collected by electrostatic precipitators from the flue gases.” It has a high 20% carbon content.

“Using coal fly ash conserves energy by reducing the demand for typical pavement materials such as lime, cement and crushed stone, which take energy to produce. Each ton of fly ash used to replace a ton of cement, for example, saves the equivalent of nearly one barrel of imported oil.”

The most important fact of life for would be pioneers of lunar industries to keep in mind at the very forefront of consciousness can be summed up in this one phrase: “The Path Not Taken.” Here on

Earth, when R&D discovers something that works very well, further experimentation on all other lines that has not yet produced equivalent promise, is halted. It's simply a matter of conserving research and development dollars. Let's translate that into a "Space Frontier Pioneering Guiding Light Principle."That R&D has been halted on a line of experimentation, doesn't indicate that there is nothing promising to be gained from pursuing it further.

We need to find people in cement industry R&D laboratories who are willing to find a way to sneak in some off-line experiments using strictly those ingredients we can produce or simulate on the Moon at acceptable energy and source material costs. Make no mistake, without that research, concrete will still be a mainstay building material on the Moon. But barring success in formulating lunar-appropriate extrudable formulations, some of the new wonder applications we are seeing here on Earth in the 90s and the current "double oughts" [as the first decade of the 20th C was called] will not be practical on the Moon. And that would be a shame.

Environmental Friendly Concrete

For the sake of argument, let's say that the suggested research is done and turns up nothing promising. Concrete would still be a space frontier workhorse even with out extruded products, without shotcrete. It can still be poured and molded and pigmented and textured. But especially interesting from the environmentalpoint of view is that concrete accepts aggregate inclusions: pebbles, stones, gravel - we all know about that. But if that is as far as your familiarity goes, you're no longer up to date. A California firm, Syndesis, [www.syndesisinc.com] has pioneered using the detritus of civilization in lieu of 'normal' aggregate:

> **Syndecrete®** is a restorative product, reconstituting materials extracted from society's waste stream to create a new, highly valued product. The advanced cement based composite contains natural minerals and recycled materials from industry and post consumer goods which contain up to 41% recycled content. Such materials include metal shavings, plastic regrinds, recycled glass chips and scrap wood chips to name a few. These materials are used as decorative aggregates, creating a contemporary reinterpretation of ... terrazzo. ... Syndecrete® uses no polymers or resins. ... a solid surfacing material whichprovides consistency of color, texture, and aggregate throughout ... less than half the weight with twice the compressive strength of normal concrete. Surfaces can be ground, polished, or textured to expose the natural porosity and aggregates. Form or mold surface finishes allow exacting detail, from wood grain to glass.

What is exciting to me about this is it will help minimize the need of lunar civilization to follow the sorry steps of their terrestrial ancestors "from mine to landfill" by creating an avenue, particularly attractive to entrepreneurs, to use the kind of manufacturing and domestic usage waste like that cited above (less the plastic and wood!) to make valued consumer goods for total less expenditure given to source materials. These inclusions have character of texture and color and visual interest, for which the energy has already been spent. Reusing that spent energy in this way will be one way to make lunar settlements more efficient and minimize what I call "throughput" - the percentage of, and rate at which, raw lunar materials pass through the lunar consumption system to end in some lunar crater landfill. **Concrete is a material with much promise** for Lunan contractors and entrepreneurs and consumers. In the newborn space frontier tradition of spin-up (not off) entrepreneurs here can help pioneer the road, for profits here and now. <MMM>

MMM #160 - NOVEMBER 2002

Recycling Glass & Other Materials in Lunar Settlements

By Peter Kokh

Many thanks to Dave Dietzler of the Moon Society St. Louis Outpost for another great article. Dave is correct to point out that as mentioned in my previous article on Concrete, which he cites, glass shards can be used as decorative aggregate in concrete. He is also correct in saying that aluminum and other post consumer "trash" can end up in that sink.

That said, we beg to differ on a wisdom of general tolerance for such kinds of disposal. There is more to

consider than that. Those materials that incorporate a lot of energy in their production should preferably be recycled
in a way that captures as much as possible of that energy.

The best way to recycle glass is in the production of more glass. The best way to recycle aluminum is in the production of more aluminum. There are plenty of rocks and aggregate rubble on the Moon to serve as filler for concrete at little energy expense. If we toss aluminum scrap into the concrete batch, that means more electricity must be generated to replace that aluminum than would be the case if we simply recycled it properly.

Glass recycling, as most of us who try to do it know, can be tricky. You have to keep the colors separate, and some kinds of glass can not yet be economically recycled at all - the mongrel glass in the so-called "disposable bottles."

There may be incentives for business to find uses for various orphan categories of post consumer waste. And there may well be an effort to design consumer products for designated afterlife usages. In the 70s there was an attempt to design a "world bottle" with a shape that would let it serve adequately as a building brick when empty. It would be a good idea to take another look at this challenge.

Today, an increasing number of businesses are seeing the economic sense of reuse design. I think that young Lunans will grow up learning the Four "R"s - "Reading, wRiting, 'Rithmatic, and Recycling." On the Moon we will always be behind the proverbial Eight Ball in fighting the odds in a never ending struggle to survive in a decent and satisfying fashion. The better we attend to our Ps and Qs, the better our chances of a good life. The more sloppy and careless we allow ourselves to become, the more quickly the curtain will fall on an a self-aborted effort to settle a new world.

Young people can be given the yeoman chores of recycling, and do their universal service in all the utility systems upon which survival on this unforgiving world is possible. That should instill in most of them a second nature habit of care and concern. Plainly put, it will take a bit more to make a good Lunan citizen than what sadly passes for a good American citizen. <PK>

MMM #161- DECEMBER 2002

Cheesy Casein-based Paints for Lunan Artists

By Dave Dietzler <pioneer137@yahoo.com> and Peter Kokh

By Dave Dietzler

A painting medium in common use by artists here on Earth, "Casein-Tempera Emulsion" may lend itself to use by early lunar pioneers. Casein [Latin case(us) = cheese] is a protein precipitated from milk and is the basis of cheese and some plastics. An emulsion can be made of this protein, water, and lime to serve as a binder for fine art paints. Tempera is a painting technique using such an emulsion. Casein sets quickly, mat, and transparent, all of the pigment is exposed, making a very luminous surface.

Early settlers may not enjoy fresh milk from goats, much less from dairy cows, but powdered milk may be a regular imported food supplement, and source of casein. You can read more on this medium and how to prepare and use casein tempera emulsions,
at:http://www.mauigateway.com/~donjusko/final.htm#CASEIN-TEMPERA

"Lunar Kosher" Considerations

By Peter Kokh

While this tempera emulsion may work with many inorganic pigments, casein, being organic, in our opinion should be reserved for use with organic dye stuffs so that waste paint and discarded artifacts can be recycled into the biosphere. Yet most vegetable dyes apparently "bleach out" when used with casein emulsions.

This creates quite a challenge for would-be Lunar Appropriate Art Media Pioneers {LAAMP} It would be great to have another paint medium than inorganic sodium silicate (waterglass) in order to diversify the art media options open to Lunar Pioneers. But how do we do achieve this goal?

Experimentation is essential. Any satisfying results may lead to a Casein-Tempera medium quite distinct from that practiced here on Earth.

This may seem an absurd concern for those preoccupied with frontier hardware questions, and even those concerned with lunar agriculture and biospherics. But in the long haul, the burden of transforming a bleak frontier into a truly human one will fall on the shoulders of pioneer artists and craftsmen who find ways to transform moon-dust-based stuffs into human expressions of beauty.

Art and craft are not luxuries. The battle for the Moon will be won or lost on a host of fronts: metallurgy and other materials science, engineering and architecture, agriculture and biospherics - we understand those. But it will be a battle not just to establish and preserve environments that sustain the body, but also a battle to establish environments in which the human spirit can thrive and reach new heights. read about our previous attempts at a lunarappropriate painting medium at:**http://www.moonsociety.org/chapters/milwaukee/painting_exp.html**

MMM #166 - JUNE 2003

Board Games for Early Lunans: Mancala or Oware, Anyone?

By Peter Kokh

Most would-be Lunan Pioneers probably take for granted that they will have access to most anything they want from Old Earth. Perhaps. Perhaps not. It seems far more likely that the do-or-die struggle to ramp up exports and production for domestic consumption to the point where enough credit is earned to pay for importing those items of necessity that cannot yet be produced on the Moon.

Production for domestic consumption and production for export will go opportunistically hand in hand. Another do-or-die struggle will be to preserve precious volatile elements, hydrogen, carbon, and nitrogen, for use in the biosphere/food production cycles as far as possible, withdrawing these elements from that "bank" on a case justified basis. Fiber for clothing, byproducts to be turned into recyclable children's art du jour another.

Game boards wouldn't seem to be a must-have item either imported, or made from biomass bank withdrawals. Not if we can find substitutes. A computer screen can host just about any game board, even if it isn't on-a-table flat or shared by both players. But traditionally printed cardboard games of Monopoly, Sorry, Scrabble, and a myriad of other board games and their 3D game pieces are not likely to show up in frontier stores, or be importable at affordable prices, with or without stiff luxury taxes.

An Ancient African Game to the Rescue

A game played in Africa for thousands of years, under many names, could be a popular, frontier produced substitute, offering many hours of pleasure for all ages, at all skill levels. Ancient Egyptians called it **Mancala**, and to many of today's Africans it is **Oware**, or simply "**Pits and Stones**." This game is ranked "among the world's best."

Recently, I purchased a hand-crafted Oware set, carved out of wood from some African tree, and found a willing partner. It took less than two games to start experimenting with "strategies" and it was quickly obvious that here was a game, seemingly so simple, that delivered great brain exercise and thrills.

How so? First, the board is carved to contain two rows of six pits, one for each player, plus a pair of special pits for captured pieces. While commonly made of wood, this is a simple game board that could easily be made of materials available in the early lunar frontier. ceramic by frontier potters or, or glass, or cast basalt. There is no "printing" involved, only shape - of course, that could be managed by a 3D printer!

Second the game pieces consist of 48 "seeds." nuts, marbles, teeth, pebbles or stones. Anything will do, and these do not need to be individualized. Each piece is playable in turn by each player, so 2-color differentiation is neither needed nor desired. All the seeds can be identical.,exactly or crudely. Think of roughly same size lunar stones, raw glass marbles or beads, metal balls.

The Game - The game starts with four seeds in each pit. The first player takes all the seeds in any of his pits and sows them one by one in four pits to the right counterclockwise, on his side, his opponents side, or both as the location of the opening pit determines. The opponent does the same, again picking as starting pit. You may now have two empty pits, and some pits with more than 4 seeds. The idea is to sow the last seed of your play in an opponent's pit with only one or two seeds, in which case you capture both his, and your own landing seed. And the capture continues clockwise if the second last pit you land on also contains one or two pieces. The idea is to capture 25 seeds (remove them from play to your capture pit) in which case you win. It will take a game or two, clumsily referring back to the instructions, before the cascade of eurekas take over your brain. Then you're off to hours of great fun.

Oware on the Lunar and Martian Frontiers Perhaps the frontier version of this game will be known as "**Craters & Rocks**." The game may prove so popular a pastime in the "New Stone Age" that permanent game tables of molded concrete or cast basalt might become a common feature in frontier parks. [www.tradgames.org.uk/images/OlindaKaliyaTable.jpg] On the other end, individually crafted hinged boards folding for portability would be heirloom quality gifts. Since sets could be manufactured in quantity from pressed aluminum sheet, yet hand-crafted in clay, glass, cast basalt or other art media, they would serve all ranges of the market from beginner to devotee. The board and pieces can be easily be scaled up or down in size.

Getting in the Frontier Spirit - Where to find the rules, ready to use sets: Just go online to www.google.com and type in "Oware" and search. You will find all you need. Hobby stores, game stores, and museum shops may have sets for sale. Let's rename the Lunar Frontier version of this game "Craters & Rocks!" Make your own out of clay, beaten tin or aluminum sheet,-poured plaster of Paris, paper maché, or wood. You might find a muffin/cupcake tin that will work. Download game instructions, and start playing.

Craters & Rocks would be great after-meeting fun for local Moon Society, National Space Society, even Mars Society chapters. At least we think so! <**MMM**>

MMM #172 - February 2004

Moon & Mars Surface "Landscaping" Tips from Winter Snow Gardens & Japanese Zen Gardens

By Peter Kokh

Settlers, whether on the Moon or Mars, will live in cozy "Hobbit Burrows," their homesteads comfortably shielded and sheltered by an overburden blanket of local regolith (meteorite-pulverized rock powder). When they visit their neighbors, or go to school or work or shopping, they will make their sorties in the "middoors" environment of shielded and sheltered passageways and thoroughfares.

What would they care about the out-on-the-surface appearance of their shielding mounds and their contiguous surface perimeters? Surface landscaping might seem to be of little concern. This may be the case for many of them, even those whose homesteads have separate airlock access to the surface, probably an upscale luxury.

Yet "keeping up with the Joneses" is a hard habit to break, and one which many pioneers may take along with them. We spoke about ways to give special decorative treatments to shielding mounds in MMM #55 MAY '92, p 7 "MOON ROOFS." Once someone does something special and it receives a spotlight moment in the evening TV news or in the Luna City Home & Gardens magazine, the race will be on for ways to do likewise, if not better.

In truth, out-vac appearances are more likely to be a civic concern relative to the approaches to the settlement airlocks, to the settlement spaceport, etc. But once there are multiple settlements some distance apart, roadside "inns" are likely to arise, and if there are more

than one, a competition of appearances is sure to rise. Similarly, the approaches to the offices of industrial park factories and enterprises are sure to be a budget line item in their design and construction.

So how would an out-vac or surface "landscaper" go about enhancing the scapes that nature has provided? That's our topic

Moonscape and Marsscape givens

On the Moon and Mars, any exposed bedrock and any given rocks and boulders already on site will become the starting point for landscapers who may choose either to leave them in place and add more scavenged from elsewhere, or to rearrange them in more artful clusters.

The same goes with the natural shape of the terrain: flat, rolling, cratered, etc. The land□ scaper may like what nature provides or to add a hill here and a dale there. All these features provide the "bones" of the landscape to which the frontier landscaper can choose to add care□ fully placed color-contrast* sculpture accents - or, of course, to leave untouched save for a few gentle tweaks.

After all, some moonscape and marsscape scenes need no help and beg to be left un□ touched. Others may be rather blah, devoid of interest, and from the settler's point of view, in need of a little "tender loving makeover."

* On the Moon, colors that stand out in contrast to the monochrome light to dark gray□ tones: yellow, orange, red, green, blue - bright greens predicted to stand out best.

On Mars, colors that are opposite or next to opposite on the color wheel from the ochres, rusts, salmons, and yellow-beiges of the terrain - bright greens and blues especially.

Tips from Winter Snow Gardens

As I write this article from a friend's home in the countryside south of Milwaukee, there is not quite a foot of snow on the ground, refreshed yesterday, and the view out the south window-wall is spectacular. True, no signs of life - except for fresh tracks of rabbits and other hardy critters - but then, of course, I am referring to plant life. It must seem to most southern□ ers (and many a maladjusted northerner, alas) that "winter" and "garden" are twoconcepts that together, just don't "compute." But I have another friend who makes his living by landscaping for whom the two concepts fit hand in glove. Some of his ideas suggest approaches future sur□ face landscapers on the Lunar and Martian frontiers might take to heart,

Even in winter, the "bones" of trees, shrubs, and some perennials still stand proud, even above blanketing layers of snow. If we have taken care to arrange those plants in a pleasing fashion, that beauty still shows in silhouette. Included are any landscaping rocks and boulders we may have added to the mix. Gardeners should think of "how it will look in the winter" when making garden and landscape improvement decisions.

To these "bones" we may have taken care to add color accents here and there. Apart from green evergreens and the yellows of tall grasses and the reds of dogwood twigs, there are garden "grazing balls" and other sculpture accents in eye-catching colors, made of metal, glass, ceramic, cement, wood, and plastic. They will be even more appreciated in winter set□ tings.

Analogy to Ice Sculptures

In Milwaukee, St. Paul, and Quebec City, (and perhaps many other northern cities where winter revelry is not uncommon) there are annual winter ice-sculpture and snow-sculpture competitions. Like the monochrome landscapes of the Moon and Mars, northern snowscapes can be magnificent desolations of a narrowed family of related shades. We can predict that frontier artists will make sculptures out of the surface rocks and regolith soils of the Moon and Mars. To the artist and sculptor, nothing is so tempting as free raw material in abundance! [In MMM #22 Feb '89, "First Souvenirs" we wrote of the imaginative creativity that arose in abun□ dance after Mt. St. Helens scattered ash all over Washington State in 1981.]

To sculptures made of raw regolith and rock, the pioneer landscaper can add sculptures of cast basalt, concrete, glass and glass composite, and metal. Crude sintered powdered iron

sculptures will hold up well as an early choice. before lunar industry has developed to the point where steel and other alloys can be produced.

Tips from Japanese Zen Gardens of Sand, Rock, & Stone

In Japan, gardens frequently include a Zen area of careful, spiritual compositions of sand, stone, and rock. These inanimate garden spaces demonstrate that we do not need trees, shrubs and other plants with which to landscape our sterile and barren moonscapes and marscapes in ways that please the eye and uplift the soul. For the zen gardener, it is all about composition, order, peace, and simple minimalism. Frontier surface landscapers are likely to turn to these Zen gardens for further inspiration.

Tips from unlikely scene: disco ballrooms & the 60s & 70s

On the Moon's nearside, where perhaps the bulk of the lunar settler population will live, even the nightspans are bright. The Sun may be "down" for two weeks at a time; but meanwhile, Earth will phase from first half to full to second half. And phase for phase, the Earth taking up thirteen times as much area in the sky and with more than four times the reflectivity, thanks to clouds, snow, and ice, shines some sixty times (read 60 X) as bright on the Moon as the Moon does on Earth. The nearside nightspan will be quite bright by our standards, like an urban area under cloudy conditions, streetlights reflecting off the clouds.

But on the Moon's Farside, the Earth will always be "down, out-of-sight and out-of-mind." So when the Sun is also down it will truly be dark. Just the stars, so many stars, and the Milky Way in undreamt of brilliance and glory. This darkness presents a hip opportunity. Brec□ cias and other moon rocks collected during road construction and other activities can be cut and polished, to reveal, under blacklight, iridescent, fluorescent spots and streaks.

The out-vac surface landscaper can arrange such cut rocks artistically, providing nightspan black-lighting from hidden viewpoints to create a fantasy scene out one's habitat periscopic picture windows. To this, farside sculptors working in glass, glass composite, and ceramic may find a way to had blacklight sensitive texture to their creations.

Perhaps the first installations to be so landscaped will be tourist resorts in the "limb re□ gions" of the Moon, where, thanks to orbital "libration," Earth is sometimes just over, some□ times just under the horizon. The attraction of such locations is the opportunity to experience in one place Earth rise, preceded at times by the city-lit hemisphere that happens to be in darkness, then Earth hovering just over the horizon, Earth-set, and the glory of truly dark star-spangled skies. Think a combination of Niagara Falls and Las Vegas. Blacklight fantasy gardens would be a natural, to be copied in miniature by some farside homesteaders and hotels and roadside inns etc.

Imagination is not only fun. It gets things moving. Take a cue and take heart. </MMM>

MMM #174 - APRIL 2004

Sub-Selene Aesthetics

SUB SELENE AESTHETICS

and Lunar Resource Usage

By Dave Dietzler

["selene": Greek equivalent of Latin "Luna"]

[sub-selene: **below the lunar surface, as in lavatubes or regolith-shielded habitats]**

Finding the elements in the regolith to perk up habitats

Having studied the element abundances reported in the Moon rocks sampled from several locations explored by the Apollo Ast4onauts, I have the utmost confidence that we can get volatiles (Hydrogen, Carbon, Nitrogen, Sulfur, Helium, Neon) and iron [Fe], Titanium, ceramics (titania, cast basalt), glass, cement, Calcium metal, Aluminum, Magnesium, Manganese, Chromium, sodium [Na], potassium [K], Phosphorus, and traces of Zinc, fluorine, Chlorine and a few other elements from regolith using processes that I and others have described. We can make steel from iron,magnesium, chromium and carbon extracted on the Moon.

Polished steel can be shiny, but most of these materials are rather gray. What about materials that are pleasing to the eye? We can use the Mond process to get traces of nickel and cobalt from iron fines. We must have cobalt to tint glass blue and make sodium silicate based azure paint for artworks. If there are Sudbury [Ontario] type impact sites on Luna we can get copper [Cu], gold [Au], Platinum, Selenium, Nickel, etc. Many of these metals can be used to tint glass and serve as paint pigments. Copper and gold have a beauty of their own.

The problem we might run into is a shortage of hydrocarbons to make chemicals and paint. Many decades after our first outposts, we will build sub-selene towns in lava tubes with bricks and cement blocks, pour concrete floors, make glass walls and windows (some of tinted glass), glass and metal doors, glass fiber cloth drapes tinted with metals, sheetrock and plaster walls.

Our need for a good range of colors

But what about color? We don't want the place to look like an underground prison or hospital. Peter Kokh has suggested flowers, green plants, birds, small fruit trees, goldfish ponds, aquariums, etc. He has also experimented with sodium silicate ("waterglass") based paintings done on glass. [see MMM #s 77, 80 - July, Nov. 1994 "Waterglazing"- www.lunar-reclamation.org/art/painting_exp.htm]

These and some tinted glass could really brighten the place up. Just a little bit of tinted glass is needed to make colored flood lights and light diffusers, so we should be able to create a variety of color effects covering large areas with lights. Neon signs and lights are also possible. [MMM #43 March '91 "Nightspan"] The world within the Moon might have the flavor of nightlife as well as the energizing effect of bright sunshine funnelled in through light pipes. [MMM #66 June 1993 "Let There Be Light"] (MMM Classic #7)

Brick and cement blockwalls don't need to be so grim. They can be covered with plaster. We all like stucco. We can also take clear glass, aluminize it and make mirror tiles to cover inner and outer walls. Steel and glass skyscrapers, like the Equitable building here in St. Louis, are often made of mirrorized glass and they look terrific.

We could build mirrored palaces within the Moon.

We can still produce lateX paint with volatiles harvested while Helium-3 mining. From 30 billion tons of regolith, an area about 100 kilometers square mined to a depth of one meter, we can get 300 tons of Helium-3, an fusionable isotope scarce on Earth but relatively abundant on the Moon, enough to power the Earth for a year. As byporducts of that mining process, we can also get 1.2 million tons of hydrogen, 3 million tons of nitrogen and 6

million tons of carbon. That should be enough to make quite a lot of plastic, paint, dyes, and other products.

If we emphasize the use of polished metal, stucco, mirrors, tinted glass, colored lights and living things to add color and make attractive interiors and ("middoor") exteriors), we won't have to make so much paint and we can use our precious H, C, and N for more important purposes.

Latex paints formulated with a high percentage of volatile organic compounds (VOCs) for fast druying, cause many indoor pollution problems. Fortunately, in the past decade, Low-VOC paints have become available everywhere from the web to your local paint or hardware retailer. Manufacturers of low-VOC paint include Benjamin Moore, Sherwin Williams, Martha Stewart, Dutch Boy, and many more. Such paints might be used in lunar habitat interiors where others would pose major headaches, literally and figuratively.

We could use colored ceramic tiles on walls and floors as well as previously described ways of adding color. {see MMM #76 June 1994 -- MMM Classics #8) As a clue to what elements we would need for metal oxide-based ceramic glazes, see:http://digitalfire.com/oxide/oxprops.htm

We may not want to go overboard with color and become gaudy. Overall, blocks, mortar, concrete, sheet metal and glass will create a sort of industrial decor like that found in pricey loft apartments built in old warehouses and factories. [MMM #s 146, 147 (June, August 2001 "Urban Lofts & Settlement Style") both republished in MMM Classic #15, a pdf file you can download from either location given at the end of this article.

Until we return to the Moon and explore some subselene lava tubes, we won't know what charms nature has in store for us that will help us make things interesting. But we already know enough to be rather optimistic.. <**DD**>

From Back Issues of MMM

Back in 1994, we took up many of these topics in MMM #s

74, 75, 76, 77 - April, May, June, August..

#74 Visual & Solar Access

#75 Modular Hab Architecture

#76 Interior Walls and Surfaces (available materials & treatments) & "Trimwork" (substitutes for woodwork)

#77 Upholstery fabrics, what to hang on walls

These articles are republished in MMM Classic #8, a pdf file you can download from of this location.

www.moonsociety.org/publications/mmm_classics/

MMM #175 - May 2004

Creating "Nature Walks" on the Moon

By Peter Kokh

Perhaps most of us have been somewhere in the countryside, mountains, forest, desert, shoreline, and have noticed a sign "Nature Trail" and decided to talk the plunge. Chances are we will have enjoyed it, and if we took the time to read all the signs attempting to inform us about what we were looking at, emerged with a bit deeper insight into nature's wonders and mysteries.

Some Nature Trails may point out a few geological features such as rock outcrops, waterfalls, and so on. But by and large, most of our Nature Trail educational tidbits are about flora (plants) and fauna (animals.) We tend to take the host geological setting for granted. And precisely because there seems to be a so much greater wealth of detail to wonder about and to delight in when it comes to plants and animals, the subtle differences in texture and color of rock and soil are at best, enjoyed as is, with no felt need to learn names, classifications, or significances. We simply take the inanimate context for granted.

I think on the Moon it will be different. Yes, we will have flora and fauna nature trails, but inside human-created mini-biospheres. Out-vac, on the barren lifeless surface, Nature Trails through the "magnificent desolation" will have only geological items to highlight and educate us about.

We do have a primeval need to identify salient things and details in our environment. It is the Adamic urge to "name" things. In the absence of visually distinctive plants and flowers and birds and other creatures to identify and "tag" with a name, I think our attention will automatically shift to subtle differences in the inanimate setting that we would not have paid attention to if plants and animals were present. Nature abhors a vacuum, goes the old saying, and so does the mind. The way this rock is shaped and textured and colored differently from that one will take on new significance and importance, without other things upon which to focus.

An Analog Moon Nature Trail Experience

This was all brought home to me most vividly in the summer of 1992, when, as the guest of Bryce Walden and Cheryl York of the Oregon L5 Society, I had a walk (and at one point, crawl) through tour of the pair of lavatubes that, at that time, constituted the "Oregon Moonbase" just outside Bend, Oregon. Being rather familiar with limestone caves full of interesting stalactites and stalagmites and other water-flow and drip-created features, I had expected a tube created by flowing lava to be rather uniformly devoid of interest. But I was amazed to see how the texture of the lava-flow-formed walls varied from place to place. I counted at least eight distinctive surface types. I felt the need to be able to identify this texture from that one and to understand what caused the differences.

These details are things I may perhaps have noted, but paid no more attention to in a setting with plants and/or animals in the foreground to hog my attention. And there we have it. Geology for most of us remains in the background, because the living foreground pops out and monopolizes our awareness. Absent life, the geology becomes the foreground and zooms into focus.

On the Moon

When we look at Apollo Moon mission footage, we notice differences, but perhaps do not dwell on them. The scene seems desolate at monotonous. Hello! There are no plants and animals – things we are used to seeing most everywhere on Earth. But for the Lunan pioneer, once the ingrained expectation of living entities no longer fogs our interpretation of what we see before us, I think we will start noticing this and that about the moonscapes – the subtle yet somehow interesting differences between this view and that, between this location and that. In the absence of other things to "recognize" by name, we will want to know the name of this feature or that, and without that information, start creating names from scratch.

A lunar settlement will soon create nature trails through areas in which there are a variety of features that are noticeable, and about which the history of their formation, the mineralogical, and potential economic importance will be of interest (again, lacking anything else – read: living – to focus upon).

With the best of attitudes towards the Moon, most of us, given the chance to take a coach tour on the Moon, will become a bit bored after a few hours or miles. We don't appreciate the distinctions in what we are seeing. Consider these parallels on Earth. Without the cultivated ability to see and appreciate differences, "when you've seen one waterfall, mountain, or city you've seen them all." Boredom is not without guilt. It comes from failure to cultivate an appreciation of distinctions and differences.

In the near and not to distant future

Nature trail education will help Lunan pioneers and visitors to enjoy what they see more thoroughly. But why wait? In the very near future, any of us will be able to go to the nearest IMAX theater and enjoy as never before possible, in wrap-around attention-captivating detail, the moonscapes actually photographed by the Apollo astronauts, thanks to Tom Hanks and his crew and Lockheed-Martin. Look for "Magnificent Desolation" to open soon, and go see it again and again. See MMM #174, APR '4, p. 12

And why not fly a photographic lander-rover to an interesting spot on the Moon, do a lot of video-taping, and have Moon geology experts edit the footage for the more interesting and significant items, and with the help of science popularizers, create a DVD or IMAX Nature Tour of this or that moonscape we can all enjoy while stuck here on Earth. In the process we will be learning to appreciate the subtleties, and find the Moon a much more interesting and intriguing place. <MMM>

MMM #176 – June 2004

Tele-Crafted Art Objects

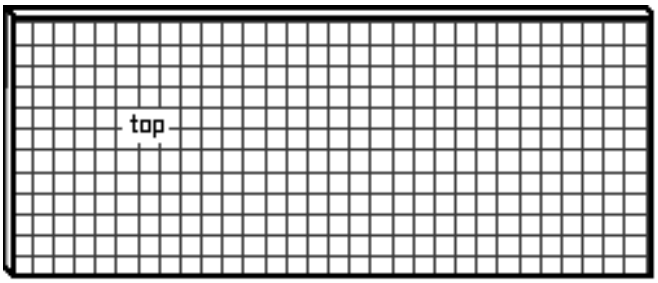
Creating Art on the Moon before the next humans arrive

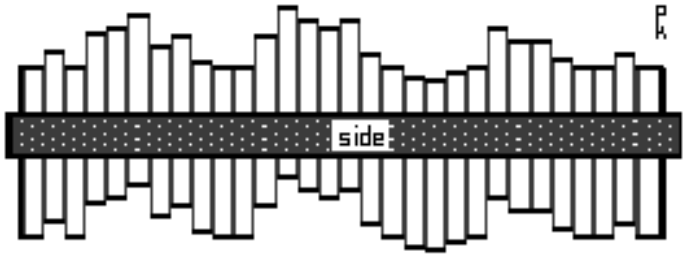
By Peter Kokh

The nest step beyond Moon-relayed messages and advertisements could be tele-art. We are still in the realm of products delivered to Earth-bound customers electronically, no physical objects shipped. What more could teleoperable landers and lander rovers do or produce for telesales on Earth? As with video games, progression from the first pingpong games to todays multi-megabyte games played on high definition screens, the potential for progress from first humble offerings to sophisticated products is great. And what better prospectus could you have for a teleoperable space enterprise!

The idea is simple. The lander, or lander-rover is equipped to make things in, or out of, the regolith moondust at its location, and relay photos of these creations back to Earth for the enjoyment of their telecreators, gift-recipients, and others. What are the possibilities?

Drawing in the moondust with a "stick" or wand: the moondust is cohesive enough to hold crude shape. The crisp Apollo bootprints are ready proof of that. Getting beyond the stick, a stamper made of teleextendible pixel rods or bars could stamp any sort of pattern/picture in the soil, dependent on its "resolution."





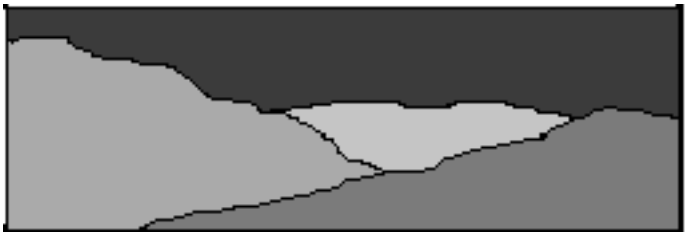
The ability to "fix" the stamping by microwave sintering would be an asset. People could order "moon bricks" (to remain on the Moon but with their photos relayed back to the person placing the order) with their own name or the name of a beloved or departed person. The stamping could be a handprint or footprint or bootprint.

Or it could be a simple message. The apparent drawbacks of this idea are (at least) these three:

1. The scale would probably have to be large, if keeping with the degree of detail and resolution desired
2. The lander rover would have to keep on the move, as it would quickly run out of stampable terrain within reach of its landing spot.
3. If microwave sintering is used to ensure "permanence" the power requirements of the rover would be greater

The next step beyond simple stamping would involve altering the moondust to telecreate art objects and sculptures out of crude moonglass and ceramics. Once we get beyond simple microwave sintering, the power demands go up along with the temperatures involved. Iron fines gathered by a magnet, could be shaped and sintered (powdered metal technology) into objects of art. Glass making would be more ambitious. A solar concentrator mirror could supply the high temperature needed. Designing tele-shapable mold aparatus would be the trick. But perhaps someone out there is up to the challenge.

Quite another idea is to sift the moondust and then run it through an apparatus capable of sorting the particles for shade and color. A teleartist on Earth could draw on the bin sorts to create "sand paintings" in twin-paned glass frames open at the top, and webcast to Earth. If these could be preserved somehow, they could be traded on some sort of Art Futures market, against the day further into the future, when they might be retrieved and shipped to the high bidder on Earth.



The same sort of thing could be done with glass spherules sorted from the moondust, and again sorted for color. The visual effect and texture of the "painting" would be different and richer. The coarser rock and aggregate bits removed by the sifting process, could always be added back in, sparingly and deliberately placed for the desired accent. Preservation of such art objects could be by microwave sintering. The big trick is to supply, or make, a suitable durable substrate for these fragile creations.

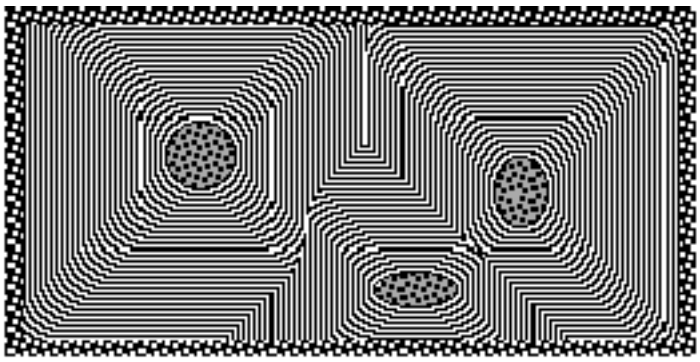
Glass and iron-fine jewelry and coins have been suggested, but again, these ideas are for the next round, when shipment back to Earth is possible and affordable. We are more concerned with objects of art that can be telecreated on the Moon, and enjoyed long-distance via the web or relayed photos, auctioned off in an Art Ftures market against the day when they might be retrieved, or become part of a lunar sculpture garden for future Lunans to enjoy.

A more ambitious idea would require a rover with a manipulator arm that could pick up tele-selected rocks or breccia aggregates and pile them up into interesting sculptures. Without some sort of glue or binder, however, this possibility seem limited to gravity-shaped piles. In that case, the art would be in the choice of rocks and the overall visual "texture." On a grander scale, a sculpture on Earth could create a lunar Stonehenge of sorts. A lunar Stonehenge could even be designed to showcase astronomical events. An installation of this sort along the 90° E or W longitudes, in the middle of the limbs, could be designed to show maximum elevation of Earth above the horizon, i.e. librational extremes. How long it takes for the teleoperated device to create any such grand object is immaterial, if the device is solar-powered. All that is of concern is that the device be strong enough to handle the largest sculpture component that needs to be moved, as opposed to being left in place.

Primitive prehistoric stone works could serve as inspiration. Such larger scale art projects would endure indefinitely, to the delight of the eventual pioneers. And for them too, such rock works would be "prehistoric," tele-made on the Moon before the arrival of first settlers. Perhaps this doesn't conjure up anything of much interest to most

readers. But then most of us do not have the unbridled imaginations of artists, and of an artist turned loose in a brand new medium!

Besides Stonehenge-inspired creations, artists on Earth could make serene Zen/Japanese rock gardens with well-selected and carefully placed rocks set in a pool of ripple-racked moondust, bordered by a row of smaller rocks.



Zen gardens can be created around any trio (the desired number) of nice boulders left in place, simply by raking the regolith around them, piling up the rake-removed smaller rocks in a row around the perimeter. That would remove the need to select and move the bigger rocks that are to be the garden's focal points.

All the artistic creations accomplished through a given lander-rover-manipulator would remain in one general area. A sunset task for this teleoperated art machine might be to grade and tamp down, and possibly sinter, a "sculpture garden pathway." Then the rover would make a final video tour complete with documentary script, with the original artists making the voice over commentary.

Such sculpture gardens would in time be visited by actual tourist visitors, from the settlements and from

Old Earth itself. Such a park could be named after the lander-rover-sculptor ("Moonsculptor I"), or after the most award-honored individual creation in the park (e.g. **Moonhenge III Sculpture Garden**), or simply after a prominent nearby geographic feature ("**The Taurus-Littrow Prehistoric Sculpture Garden**.") The finishing touch of working all these tele-creations in a Garden Park would help counter those who object that we are "defacing" the Moon.

Without the presence of weathering agents other than the light incessant micrometeorite "rain" that should take many of thousands of years to erode the Apollo bootprints, these creations will endure in their exposed setting for a very long time. The more highly-valued can always be relocated within some future settler museum.

Prospects for Tele-art on the Moon

We are not talking about art created by robots - robot art. Real human artists on Earth, their hands inside virtuality teleoperation gloves, would go through the motions of placing, shaping, working moondust and moon rocks into the object conceived in heir heads. For first timers, this will be a learning experience and preconceived ideas of what they will be able to do may quickly go out the window as they learn hands on what they can and cannot do, both via teleoperation, and with actual moondust and rock. Some will get the hang of it faster than others. And some will produce objects of more widespread appeal than others.

Can we do the same thing on Mars?

There is less than a 3-second time delay in the execution of a teleoperated command on the Moon. For Mars thw delay would range from 6 to 40 minutes. The long answer, however, is yes. One could create a teleoperation program and let the computer execute it, removing the artist from the time delay loop.

Outside of contracts for future delivery, money might come from friends of art sponsors and benefactors, or by sale of lottery tickets for the chance to tele-craft, to extend one's artistic abilities virtually to an alien material on an alien shore. A considerable fringe benefit may be from media exposure and publicity. precedent of treating the moonscape with artful respect will strengthen the case for prior agreement on environmental protocols. The Moon has no biosphere to pollute, but that does not mean that it can't be visually "trashed." Tele-created art objects may lead to prior setasides of geological and scenic preserves, and other guidelines that will guarantee the Moon remains beautiful for its future inhabitants. Meanwhile, the expectation that pioneers cannot be far behind, will spread. <MMM>

The Exotic Moon:

The Exotic Moon:
In Search of Color & Beauty

Available Media will Challenge Frontier Artisans

By Dave Dietzler

Recently, I went to an art gallery here in St. Louis called Macro-Sun International to listen to a sitar player and see some belly dancers. There were plenty of statues of the Buddha, Siva, Ganesh, dragons, elephants, Krishna and lots of fine furniture, clothing, jewelry and incense on sale. Some of the statuary was made of carved stone, but most of it was made of wood or copper.

Once again our limited stable of lunar materials raises its dragon's head to challenge us. We can forget about wooden carvings on the Moon except for the most wealthy men and women alive. Given the geological reality of the Moon, unless we find that Sudbury type impact we dream about we can forget about copper, zinc, tin, brass, bronze, gold and silver. Lunar artisans will have plenty of stone, cast basalt and iron to work with, but not much of the traditional materials.

I guess the bright side is that there won't be any competition with plastic on the hydrocarbon poor Moon, if anybody wants a plastic Siva!! Imagine artisans casting and hammering aluminum, magnesium and titanium in solar furnaces with the use of free lunar vacuum. Red hot magnesium, a fairly soft metal, will catch fire in air but our lunar artisans may do some original work in the vacuum with it. We could have plenty of shiny grayish or silvery statues of these metals. We might even chrome plate them. A chrome plated aluminum Ganesh will truly be a creation of the 21st century!

For the want of yellowish metals we can work with pure iron and then expose it to hot sulfur vapors to form a pyrite finish, a coating of fool's gold. We could put pure iron statues in hot oxygen baths to form a rusty red coating.

But what about glass? I noticed a dearth of glass items in this gallery. Has glass never enjoyed the popularity in Asia that it has in the West? Besides glass flowers and cut glass work, how about a glass Buddha or eight armed Vishnu riding a lion? On sandy silicate covered Luna, we will have plenty of glass and our oriental artisans may find lots uses for it. I can see clear, frosted, iron tinted green and brown glass elephants as well as shiny black cast basalt elephants and dragons. I am sure that it will be more affordable to transport artisans to the Moon and put them to work using local materials than it will be to ship kilotons of finished copper, gold, wood and ivory times to the Moon! I hope they enjoy the challenge of working with lunar available materials as much as we do (at least Peter Kokh and I).

We have discussed neon signs, red and cobalt blue glass filters over spotlights, prisms to cast rainbows of color (some prism fiber-optic light pipe systems will be large enough to illuminate stages with selected colors), plants, flowers, tropical fish and birds to add color to our
lunar dwellings.

As I watched the girls belly dancing, I realized that there were other colorful creatures to jazz up those steel and underground lava tube enclosed lunar cities we intend to build someday -- human women with all their finery. Colorful silks, jewelry, cosmetics and such don't amass too much and the girls will be bringing luggage with them anyway.

Going to the Moon is not going to be like going to a hospital and being forced to give up your clothes and wear those humiliating hospital pajamas nor will it be like joining the army and being dressed up in a uniform or going to jail with all us cowards. Travelers will have their own clothes, although they might have to wear a G-suit to keep from passing out or getting sick during rocket ascent to LEO.

The fairer sex will have their feathers and dance for us. That will add color to the exotic Moon. Perhaps we
can sell them some cobalt blue tinted glass jewelry while they are up there too. <DD>

MMM #181 - DECEMBER 2004

Carving & Sculpting on the Early Frontier

By Peter Kokh

A Gift from Santa - AAC

December 1, 2004 - UPS just delivered a heavy box. An 8"x8"x24" piece of AAC, Autoclaved Aerated Concrete! It weighed 35 pounds (out of the carton) whereas the same volume of water would weigh about 57 lbs and of normal concrete about 127 lbs. I figured its specific gravity at 0.61 (water is 1.0,

rock 2.8) and, yes, a chunk of it does float. I took it down to my workshop right away. With plenty of experience in carpentry and other home repair and remodeling skills,

I have been on the lookout for years for a substitute for wood that Lunar craftsmen and others could use. So when Dave Dietzler (frequent MMM contributor from the Moon Society St. Louis chapter) sent me an email some time ago about AAC, I followed the links and noted that one of the hyped characteristics of AAC was its "workability". That was my button! I had to have some to see for myself. Following the online trail, I sent out a few emails. The wait was worth it.

The Unveiling

The block seemed to be heavy because it was so big. A couple of smaller chunks had cracked off in shipment, and picking them up you could tell it was light stuff. I reached for my tools, and

- You can easily saw it with a hack saw, and even with a regular wood saw.
- You can carve it with a wood chisel or a shaping tool.
- You can cut it with a sharp knife (but it produces granular debris rather than shavings because, unlike wood, the material lacks fiber and an oriented grain.)
- You can easily drill it with a metal bit, and even with a paddle wood bit
- You can pound a spike into it without splitting the material.
- You can drive a screw into it
- Working AAC produces a "sawdust" more coarse than wood working dust, but, surprisingly, not very abrasive.
- You can sand it to produce a smooth surface

And so?

This stuff, if there is no problem producing it on the Moon, will certainly become popular with Lunan sculptors and not just with transplanted chain saw wielders. How easy is it to work? Let's put it this way. AAC is harder than balsa wood, softer than pine., much softer than oak.

Now its ease of carving and shaping is a double edge sword. Being non fibrous, an AAC sculpture could break easily on impact -- if you dropped it (low lunar gravity to the rescue?) and could be scratched, gouged, marred easily. Could you give it a protective coat or skin, using only inorganic materials producible on the Moon? The brainstorming and experimenting continues. < MMM >

MMM #182 - FEBRUARY 2005

Making Music without Importing Instruments

Music from Junk

Monster Musical Instrument Shop

By Peter Kokh

The Frontier Situation

Music without musical instruments? That's easy. Our computers can generate any music we want. That may satisfy some, but not all. Some artistic souls will want to generate music the old fashioned way. Yet musical instru-ments will be luxury items imported only at exorbitant cost. A ban on importation of musical instruments would not stop the music, however. Instead it would encourage and energize an amazing creativity.

In MMM #3 March 1987, "Moon Music*" we took up this challenge.

http://www.asi.org/adb/6/9/2/2/003/moonmusic.html

Republished in the first volume of MMM Classics:

http://www.lunar-reclamation.org/mmm_classics/mmmc1_Jul2004.pdf

We can make some kinds of instruments out of lunar materials, but. But forget anything made of wood, copper or brass. Iron, steel, aluminum, glass, concrete, ceramics – yes. wood, copper or brass – no. Wood
incorporates hydrogen and carbon that should be recycled to maintain the biosphere. Copper, from which brass is made, exist on the Moon, so far as we presently know, only in economically irretrievable traces. That leaves out most wind instruments.

Ingenuity will come up with substitutes. Incredibly beautiful music can be made from a cut-off 55 gallon drum whose bottom is then beat with a set of sledge hammers into a complex concave shape capable of sounding from 3 to 36 full, round, vibrant notes. We can make music with glass tumblers and ceramic tubes etc. The article cited above had many more suggestions.

"Scrap" will be a "lunar material" also

But in addition from fashioning musical instruments from scratch out of processed lunar materials, some frontier artists may choose to simply make them from "junk" or "scrap." We recently read the article "Recycled Rhythms" in the column "One Small Step" in Sierra – Jan/Feb 2005. The article told the story of **Donald "the Junkman" Knaack**, Percussionist, Manchester Center, Vermont. Visit his website: http://www.junkmusic.org

Knaack uses only junk metal – wrenches, pipes,etc., chains, brake drums, hub caps, pan covers, seashells etc. – we can use items discarded by manufacturers as seconds and by consumers as broken, or just as "replaced", spent artillery shells, rifle barrels, Scrap metal parts of many kinds will lend themselves to percussion sounds.

Beyond Percussion

But some shapes, of metal, glass, and ceramic should yield bell-like notes with a distinctive pitch, A mix and match "full set" of them would allow the artist to render almost any melody of whatever beat.

Whereas traditional musicians attempt to use recognized instruments with fairly standardized types of sounds, Lunar and Martian pioneer "junk musicians" will be more inclined to experiment. And if their ensembles do a poor job of rendering known and cherished melodies, they will just create music specially tailored for the instruments they have fashioned. The "sound" will be unique. Junk Music could become a popular genre on both frontiers, adding much to the specialness of space frontier cultures.

The music will not be "refined" but neither will the spirit of frontier folk be refined. Refinement will come over generations, as frontiers become less rough and rugged, and survival becomes less problematical.

The Lunar & Martian Junkpiles

The junk will come from abandoned and derelict space ships, from broken down rovers and overland coaches and rigs; from fuel tanks and shipping containers. It will also come from the detritus of frontier industry. And surely, some of it will come from the consumer cycle. Agricultural "scrap" will also do at least temporary duty in music making. Hollowed out guords, bamboo pieces, just plan sticks, and wood, and reeds, and ... the list goes on.

The point is that junk is here and now, whereas specially designed and fashioned instruments made from the new suite of processed lunar and Martian materials will come on line more slowly. More importantly, "junk is junk-cheap." While instruments imported from Earth will be exorbitantly expensive, those carefully fashioned from the new frontier –processed materials will embody the costs of the processing and manufacturing, assembly and tuning, etc. Cheaper, but not free.

Frontier Junk Music as an Export to Earth

Junk Music is of terrestrial origin. What "the Junkman" has done is but to call fresh attention to a type of experimental musical expression that has always been with us probably since long before the dawn of recorded history. But it has definitely not been mainstream as more "cultivated" music has long prevailed. Fresh is good, however, and whether or not the Knaack's music catches on is not the point.

On the frontier, Junk Music may take on a prominence that it could never attain here, a prominence out of necessity. And it will be good, and fresh. It will inspire and enhearten the pioneers. Whether they gather to hear impromptu "junk jams" or practiced "junk concerts," this is a musical tradition sure to be on our road to the stars. At the outset at least.

One cannot believe that this raw, rugged, brash sound from the lunar and Martian burrows will have its devoted fans on Earth. There will be both recordings and live telecasts and webcasts.

Some terrestrial youth may be inspired by it to dream of joining the pioneers. Others will be turned off, probably for the better. The early frontier will be a rough place, where sacrifices are made, but the rewards of leading significant lives and helping launch new worlds will be great.

Starting a frontier tradition now

In the 1987 article, I proposed that chapters try to put together "lunar ensembles" that would use only those instruments that could be fashioned from readily available lunar-processed materials. Whether they only played "frontier filk" songs or also re-rendered popular terrestrial favorites, their music would give color, life, and detail to the otherwise blank visions of life on the lunar frontier. To our knowledge, no one has taken us up on this proposal.

An ISDC pipe-dream

When on the road trip home from ISDC 1993 in Huntsville, Alabama, Dave Dunlop and I decided to bid on hosting ISDC 1997 in Milwaukee (we lost this bid to Orlando by one vote, but successfully re-bid for the 1998 event), a lunar ensemble was part of our grand design for the banquet entertainment. Alas, this, like many other planned special features, this was something that required both a lot of lead time as well as the right person to head it up. "Lead time turned to lead (the metal)" as it is wont to do, and the right person never came along.

What about at M.A.R.S. or at M.D.R.S.?

Perhaps some individuals volunteering for future two week crew assignments at the Mars Arctic or the Mars Desert Research Station will take up the idea and get something started. Despite efforts to recycle, both facili-ties produce their share of trash laden with unsuspected potential: broken parts from machinery and equipment; tin cans and other containers: and more.

Willing crew members could experiment with this stuff, carefully collecting objects that produced distinctive sounds. If persons on following crews kept adding to the salvaged music making stuffs, eventually the "junk jam" that resulted would start to sound really good. A few recordings sold at Mars Society Conventions and at the annual ISDCs and the bug would start to catch on.

Others could experiment at home. Each new convention or ISDC could schedule a "junk jam" and perhaps a quickly rehearsed "concert." And Voilà! A frontier tradition will have been born. As Robert Zubrin has remarked, there has been no frontier without its special music and heartening songs and event-remembering ballads. Music may seem the least important aspect of a frontier opening effort. But in some ways it might be one of the most critical elements of all. "Shall we jam?" <**MMM**>

Favorite Hobbies, Pastimes, & Activities:
Pioneers won't have to give up "Everything"

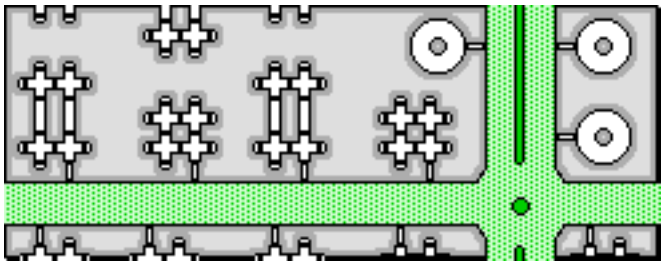
By Peter Kokh

The Moon is not another Earth

The Moon is quite a different environment than our familiar home planet. You can't go out under the open skies without a space suit. The sky isn't bright blue or even cloudy. There is no "weather" as we know it. The sun does not set every 24 hours, nor rise at that pace. There is no native vegetation nor wildlife. No outdoor sports, no nature walks. No planes flying overhead. No oil, no coal, no gas. No rivers or lakes or beaches. No forests, no grassy plains, no snow-packed ski slopes. "Boring!" as the young would say.

Recreating as much of an "Earthlike" Environment as we can

That said, we will establish local biospheres, and, if they are to survive & thrive, ones with substantial 'middoor' spaces filled with diverse vegetation and even with a carefully selected wildlife ecosystem. So whereas 'the' outdoors on the Moon, the famous "magnificent desolation" is quite inimical to life and unprotected pursuits of any kind, the pioneers will enjoy a created "outdoors" within the biosphere airlocks, an environment that falls neatly between the indoor spaces of individual residences, shops, factories, schools, offices, etc. and the "out-vac" airless spaces of the Moon's surface, exposed to the vagaries of cosmic weather. The middoors will offer much, but hardly all, of the pleasures we might at first thought be leaving behind forever.



The "Middoors"as key Biosphere Component

In a modular settlement, allowed to grow as need be (not a fixed size megastructure based on someone's guesstimate of future needs), modular habitats and other structures are connected to pressurized residential commercial "streets." These "commons" will contain the bulk of the settlement's biomass and biosphere.

See "Being able to go Outside" pp. 5-6, MMM # 152 FEB '02 reprinted in MMM Classics #16, pp. 9-10.

http://www.moonsociety.org/publications/mmm_classics/mmmc16_July2007.pdf

We have to stop thinking about living in tin cans hosting a few house plants and instead thinking of lunar habitats as ecosystems of vegetation hosting people. If we build in "full" modular fashion, expanding the biosphere along with the pressurized maze, erring in favoring plants over people rather than the other way around, we will create vibrant ecospaces, not a sterile engineering ones. And such spaces will support many of the hobbies, pastimes, and activities we feared we would be leaving behind forever.

Of course, we must forget about sailing boundless seas stretching from horizon to horizon, of flying from anywhere to anywhere, of climbing tall snow-capped mountains, of hacking trails through tropical rain forests, of doing a lot of things, to tell the truth. Yet, in smaller, restricted confines, some of our favored hobbies, pastimes and activities will find exuberant expression on the Moon.

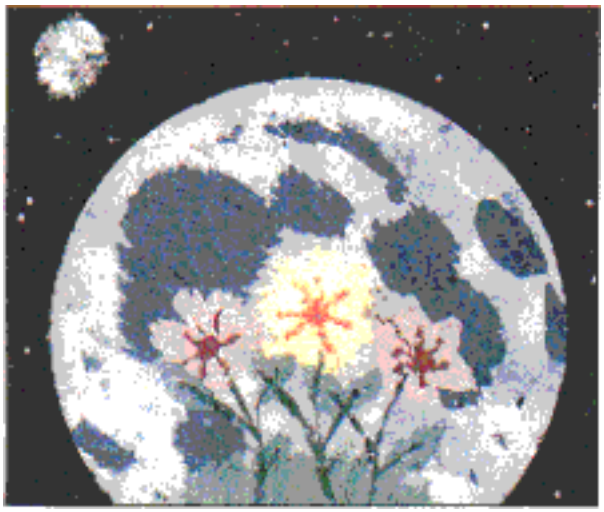
The inevitable depression and sadness that comes from the initial experience of loss, only to be eventually replaced with the newfound joy of meeting an old long lost friend, has occurred countless times through human history as peoples have migrated from location to location, changing niches and climes as they adopted unfamiliar settings. Much of what they thought they must leave behind forever, they would eventually find a way to transpose, to translate, to reexpress in the new territory.

Carpenters and builders might have left their favorite woods behind, but found new trees with woods almost as good, or even better, with new exciting grain.

Potters, gardeners, weavers, all sorts of artists and craftsmen and tradesmen and hunters and fisherman will have had similar experiences.

It takes time, of course, and having the right positive attitude surely helps. And so will it be when we migrate from "The Green Hills of Earth" to the sterile gray hills of the Moon.

Arts & crafts media (paints, ceramics, metals, fibers)



"**Moon Garden #1**" was reverse painted on an 8"x10" piece of glass, by MMM Editor Peter Kokh in September 1994.. The "paints" were not solvent based and incorporated no organic additives. Instead an inorganic adhesive (the only one known), sodium silicate, was used to suspend either raw regolith powder or colored metal oxide powders. The palette is still limited and the art form undeveloped.

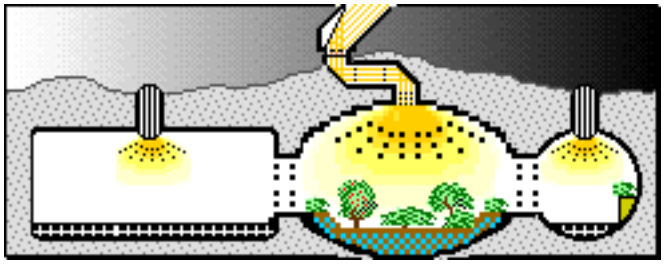
The media familiar to our artists may not be the same, but in time, we will develop paints and clays, alloys, and waste biomass fibers out of which lunar pioneers with a creative artistic bent will do wonders, filling homes and public places with beautiful objects, made on the Moon, of moon-stuffs. To some extent, we can pioneer those media, or at least analogs of them, here and now while we are waiting. Any activity along those lines would give frontier artists and craftsmen a helpful head start. See:

http://www.moonsociety.org/chapters/milwaukee/painting_exp.html

While at first, there may be very few crops, all staples, and only a few species of biosphere support plants, this will change, and quickly, if attainment of biospheric self-sustainability is a goal. And home gardeners will be a major part of this, and cottage canning industries as well. Garden stuffs will support arts & crafts, especially among children, as they do today, here on Earth, everywhere.

Gardening, flower craft, canning

While at first, there may be very few crops, all staples, and only a few species of biosphere support plants, this will change, and quickly, if attainment of biospheric self-sustainability is a goal. And home gardeners will be a major part of this, and cottage canning industries as well. Garden stuffs will support arts & crafts, especially among children, as they do today, here on Earth, everywhere.



The Heart of a Lunar Home: An "Earthpatch"

On Earth, if there is a feature that is considered the "heart of the home" it is the "hearth." Real fireplaces are a highly unlikely feature for Lunar homesteads. But pioneer homes will have a "heart" nonetheless, the interior Garden, a veritable "Patch of Old Earth." The "Earthpatch" will be important for much more than strong morale!

See pp. 3-7, MMM # 148 p. # — SEP 2001 - reprinted in MMM Classics #15, pp. 40-44

http://www.moonsociety.org/publications/mmm_classics/mmmc15_Jan2007.pdf

Goodies from Homestead Gardens – What do fruit jellies and preserves, deserts with special ingredients, herbal teas, specialty wines, organic dye stuffs, specialty house plants, craft papers, gift items, and family morale have in common? They are all possible products of pioneer homestead garden cottage industry enterprises.

We have written much and often about the role of homestead gardening in the frontier settlements:

- MMM #2 FEB '87 "Moon Garden" republished in MMM Classics #1 http://www.moonsociety.org/publications/mmm_classsics/
- MMM #109 OCT. '97, pp 3-11. Luna City Streets
- MMM #149 OCT. '01, p 5. Homestead Gardens & Early Cottage Industry
- MMM # 65 MAY '03, p 3. Settlement Garden Tours, a Favorite Pastime

Sculpting & carving & carpentry

No marble, no soapstone, no sandstone, no ivory, no whalebone, no wood. No copper, brass, or pewter. What's the frontier sculptor, carver, and carpenter to do to express what's inside himself by exposing it in a material? We will have to explore new media, probably less easy to work with. The stable of lunar-formable alloys is not yet clear. metallurgists will definitely need to be on the lookout for alloys that are "workable." There is every reason to start the search now. We know what alloy ingredients are economically available on the Moon. Let's experiment!

Are any types of moon rock carvable? Probably not, but we can cast basalt. As to wood carving, the wood from many fruit trees, especially apple, cherry, and pear, is hard enough to make beautiful adornment items. Wood will be an accent item, not a main "stuff." For example, we will see metal cabinets with wood handles, the opposite of what we are used to. The carver can work with AAC, autoclaved aerated cement. We ordered samples, and you can nail it, drill it, saw it, and carve it. The sculpting and carving stuffs will differ, the inspiration and creativity will not.

Fishing, boating, nature walks, flying

The corridors and streets of the settlement must support the bulk of the biosphere mass. There is every reason to believe streams, ponds and waterfalls will be integral parts of the water recycling system. Ponds and streams will be stocked with game fish as well as ornamental varieties. Canoes and paddle boats will be common. There will be nature paths, pointing out the various plants and other features. Chains of such walkways could be a proud and much used feature.

Eventually, if the nitrogen which will be by far the most expensive component of air can be found in ample enough supply to support open spaces with high ceilings, human powered flight should be possible in the light gravity. This will not be a satisfying substitute for seasoned pilots. But the young, growing up on the Moon, will hardly complain.

For rockhounds

Those into rock collecting, cutting, and polishing may miss their familiar favorite rock types. There are no sedimentary rocks on the Moon, no marble or granite, and probably no geodes. But there are types of rock on the Moon not found on Earth and rocksmiths will soon figure out how to reveal their "hidden essence and beauty," and make objects of art and decoration, even jewelry with them.

Japanese style sand and rock gardening should be an early favorite using larger surface rocks well placed in a regolith "pond" well-ripple-raked.

Ceramics and pottery will have to begin by making clay from scratch. Then mixing in various types of natural regolith and lots of experimenting. With cast basalt pieces, these media will be the source of much that is special and unique to tourist shops stocked with made on Luna items.

Sports – Terrestrial sports for the most part would make poor imports. With one sixth the weight and traction but full standard momentum, any familiar game could be but a caricature of the original, when imported to the Moon.

The pioneers will develop their own games, sports events, rules, playing fields etc. Some of them might make for good telecasting to fascinated watchers on Earth. {ABC's "Wide Worlds of Sports") The same goes for popular artistic dancing (e.g. lunar ballet, lunar ice skating) In short, those of us who enjoy athletics and energetic exercises, as such, or in the form of sport or dance, will still enjoy them on the Moon, though the forms may be different.

In short, no matter what kind of hobby, sport, or pastime activity you are into, there will be something for you on the Moon. It may not what you are used to, but it will tap the same energies, th'e same free spirit, the same creativity. Lunan pioneers, with the right spirit, will find many outlets for their energies. <**MMM**>

MMM #188 - SEPTEMBER 2005

Carved Basalt

By Peter Kokh

In a number of past articles through the years, we have talked about art forms that might be available for Lunan Pioneers, supportable by materials processed locally on the Moon. The Moon will not be a source of granite, marble, soapstone, sandstone or other materials favored through the ages by sculptors on Earth. Without an economical source of copper, brass, bronze, and pewter will not be available media. But Lunan sculptors, we noted, could work with concrete, glass, and various metals. Art du Jour temporary sculptures could be created by children from various garden stuffs. More recently, we introduced AAC, autoclaved aerated concrete, as a possible medium.

All this time we were ignoring an obvious sculpting material abundant on the Moon: basalt. Basalt has been carved into objects small and large throughout the ages by many peoples. Basalt carving continues today, with newer tools such as titanium tipped chisels and various abrasives. Now we had indeed written about "cast basalt" as a hard durable material that could be shaped into all sorts of useful and decorative items. But casting and carving are two different things.

The lunar maria or seas consist of congealed lava flows: basalt. But all available surface basalt has been pre-pulverized to several meters down by repeated meteoritic bombardment. That is why the use of basalt as as a carving material never occurred to us; we thought only of casting it.

But significant quantities of non-pulverized, non-fragmented basalt should be available for quarrying from the walls of the numerous lava tubes to be found below the surfaces of the various maria. Lavatubes are a natural feature formed by the way the lava sheets flowed across the lunar surface, filling the major nearside impact basins.

We did a Google Image search for carved basalt and on basalt carving methods and tools. This is indeed a promising medium for future pioneers, one that will yield many decorative objects for frontier homesteads. Perhaps more importantly, carved lunar basalt items could become a significant source of export income for the settlements.

To see for ourselves what promise this material holds, we ordered a 3" Scarab of basalt carved in Egypt, for about $30 plus shipping. This item is on display at Lunar Reclamation Society events..
<**MMM**>

MMM #192 - FEBRUARY 2006

COLORING THE MOON: THREE MORE OPTIONS

By Geoffrey A. Landis

Editor's Forward

We welcome this substantial contribution to the topic of introducing colors into our Lunar frontier outposts and settlements. In MMM #191, Dec. '05, we had updated our previous article "Color the Moon anything but gray" which appeared in MMM # 63 March '93, p 10 - included in MMM Classics Vol. #7. We had also touched on the subject in an article about how pioneers would learn to love the Nightspan in MMM #43, March '91, p. 4 "Nightspan" -now included in MMM Classics #5.

There will be many ways to introduce color in addition to oxide tints processed from the regolith: colored bulbs including neon tubing, clear water-filled bottles with drops of vegetable food dyes, stained glass, organic dyes for fabrics; and plenty of vegetation including multi-colored foliage and flowers. A carefully selected ecosystem for interlinked public spaces may include some songbirds, butterflies, and other animals. Aquaria with brightly colored fish will be popular.

Geoffrey Landis adds three chemical pathways to introducing inorganic colors that we had not thought of.

Colors on the Moon don't have to be mineral pigments based on iron, titanium, and aluminum oxides plus sulfur. Here are three additional sources of colors from lunar materials:

Color Centers

First, we can make colors by the use of color centers in glass. Think of rubies and emeralds. They are brilliant red and green, but the material itself, beryl, is almost colorless. The color comes from color centers (often known as "F-Centers", from the German), which are defects that interact strongly with light, created by doping with a small amount of a foreign element. Color centers don't need to be created only in precious stones, however, and it is easy enough to make colored glass using tiny amounts of a dopant to color a much larger amount of glass. Glass is likely to be one of the first things we make on the Moon, and colored glass could be an early product. Grind up colored glass, and you will make a pigment out of it; glue the colored glass to a surface, perhaps using a lower-melt-temperature glass as the binder, and you will be able to enamel or glaze a surface in many colors. Or, perhaps stained glass might end up being the decorative craft best suited for the Moon. One problem with color-centers in glass, is that they tend to bleach or blacken with exposure to ultraviolet. So,if you want a color that stays bright even after years of exposure, colored glazes and stained glass are likely to be a source of color for the inside of the habitat only.

Iridescence *

A second source of color that is a natural for the Moon is thin-film iridescence-- the "soap bubble" effect. A film of a transparent oxide can be made so thin that it reflects only a single color of light. Perhaps you've seen jewelry made by forming thin films of tantalum oxide on metals? That's iridescence. This forms the color for most butterly wings, as an example. As it turns out, this technology is incredibly easy on the Moon-- aluminum, silicon, and titanium are three of the most commonly available oxides on the Moon, all three oxides are quite transparent, and all of them can and have been used to make quarter- and half-wavelength films. And the method for making high-reflectance half-wave films are simply vacuum deposition-- a technology that couldn't be better adapted for the Moon, where vacuum is free. Almost any metal object could easily be colored in all the shades of the rainbow. The films will be hard (although, if you're coating aluminum, scratching the object will scratch through the film into the metal; there's no protection if the metal itelf is soft.) And, since the thickness of the films is so low (typically below a micrometer), they don't radiation darken very quickly-- an iridescent metal coating will stay colored for a long, long time.

[*from the Latin word for rainbow. Thus Sinus Iridium (Bay of Rainbows) in northern Mare Imbrium (Sea of Rains)

Nanoparticles

The third source of color to consider is nanoparticles. I'm not talking "real" nanotechnology here; it's not even really high technology. Small particles, with sizes ranging from a few tens of nanometers up to a micrometer or so, can interact very strongly with light, producing colors. To make a paint, you would have to manufacture these nanoparticles and then disperse them into a binder. In its most elementary form, nanoparticles of gold have been used from antiquity as a method of coloring stained glass (the mechanism is different from the F-center mechanism discussed above, by the way), and nanoparticles are being studied for a wide variety of other applications, of which paint is not the least. So it is very likely that, by the time we're looking for coloring agents, nanoparticle fabrication is likely to be available. <GAL>

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- Member of the Moon Society Board of Advisors; also a published science-fiction author of note.
- We highly recommends his novel “Mars Crossing” Tor Science Fiction (2001) ISBN: 0812576489

MMM #204 - APRIL 2007

Lunar Zen Gardens Inside & Outside
The Blending of Interior and Exterior Spaces

By Peter Kokh

In last month’s Mars-theme issue, we discussed how Martian pioneers could blend indoor and outdoor spaces. These pioneers will be working with a different color palette, and eventually, with something more than sand and rock: plants, once Mars-hardy plants begin to take root out in the open under a steadily thickening and warming atmosphere.

On the Moon, we have just regolith (sand analog) and rock to work with. Fortunately, these two elements have been media enough for artists in many cultures from the Stone Age through the present. Stonehenge comes to mind, but that, and many similar pre-Celtic creations are evidently something more than artful arrangements.

When it comes to sand, be it desert or beach sand, people (and children) have been drawing patterns and pictures in them with a stick from time immemorial.
http://hebert.kitp.ucsb.edu/sand/tradition.html

But the most refined art form combining sand and rock is arguably the classic, serene Zen Garden, in which an odd number of different shaped stones or rocks are placed in a “sea” of sand, complete with raked “ripples.” This is an art form that begs to be translated with lunar elements found everywhere: moondust and boulders.

We can do this out on the surface, but also indoors: below is a design perfect for a lunar home foyer.

Zen Gardens in Lunar Homes


Small **tabletop** Zen Gardens in dens, bedrooms, anywhere people will enjoy having them. A strange but fitting companion for a small Zen Garden might be a **Bonsai tree** planter, representing the forests left behind on Earth.

If there is a Zen garden just inside the airlock, there could be another just outside, especially if it is visible, along with persons coming and going, through a periscopic picture window. The garden outside, though constructed of thoroughly natural elements, puts a friendly, welcoming human touch on what otherwise may seem an alien and hostile landscape.

Inside, the Zen Garden will look the same only with very careful preparation. The moondust must first be purged of the troublesome fine powder component, the last thing we want to bring inside our living spaces. Then, using a magnet, one must purge as much of the iron fine component as possible. Why? Because the moondust has never been exposed to humidity before, and will begin to take on a rusty color instead of its characteristic gray tones. The effect would look somewhat Martian. An option would be to use controlled gradual purging of the regolith so that nearest the outside (nearest the airlock) gray tones would predominate, gradually shifting towards rusty shades at the end furthest from the airlock. This could symbolize an assimilation of the lunar environment.

Of course, there is no reason to limit placement of small indoor Zen gardens to the airlock antechamber. They might be even more appreciated in the foyer of a lunar homestead at the entrance to the home from a pressurized settlement street or passageway. Far more visitors will enter lunar homes from other pressurized areas than directly from the out-vac, the airless surface. As such it will be a statement that this is the home of Lunans, people at home on the Moon, welcoming others who have also made that passage.

Zen Gardens out on the Lunar Surface

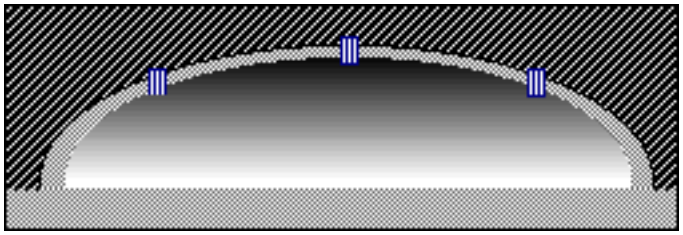
There is no reason to restrict Zen Gardens to the airlock entrance areas. On the other hand, as they take some labor in a space suit to create and arrange properly even if all the elements are handy to the location, we are unlikely to see the median strips in lunar versions of our divided highways in the form of a continuous Zen Garden!

We might see them as periodic trail markers, at road junctions, scenic waysides and rest stops. Wherever we create them, they will remind all who pass and enjoy them that we are Lunans, people who have come to live with the Moon in harmony. Zen Gardens, whether indoors or out on the surface, will be a respectful way of saying that we will make the Moon a human world, even as it reshapes us as Lunans into its own people. <**MMM**>

By Peter Kokh kokhmmm@aol.com

In his latest book, "**How to Live on Mars**" Robert Zubrin comes to the topic of **skinsuits,** that hug the body, allowing much greater freedom of movement, and with much less fatigue. That's the good part!

While skinsuits will most likely be inferior when it comes to handling radiation and thermal extremes, these dangers are excluded in sheltered or shielded "lee" vacuum situations within lava tubes and in unpressurized warehouses and sports arenas (illustration below) that are sheltered from the cosmic weather. It is in these environments that we are to see widespread skinsuit use. Such suits are lightweight in comparison and allow much greater freedom of movement. More comfortable to wear, they will allow people to work and recreate for longer periods without becoming tired or exhausted.



See www.moonsociety.org/images/changing/lee-vac_arena.gif

Skinsuits are revealing

But we gain this comfort and ease at the price of embarrassment. Because a skinsuit is form-fitting, it will showcase all the varied imperfections of one's own body shape. Potbellies, wide hips, flat breasts would all be revealed. Some of us will take that in stride. Others would predictably not be caught dead wearing such a suit.

Or so Bob Zubrin predicts!

But there is an answer: **lightweight outerwear that can partially moderate body shapes, and distract with color and pattern as well.**

Skinsuit "Outerwear"

There could be hats, capes, robes, overalls; you name it. Meant for wear in vacuum over a skinsuit, these apparel items could be made of most anything cheap and easy to work with: woven metal fibers, even wires, yes even medieval style chain mail; scrap cardboard, fiber glass fabrics, metal plates strung together – the adventures of "trashure" (transforming trash into treasure.) Any material or style that will distract attention from bodily imperfections, yet not make movement cumbersome or awkward, will become something with which to experiment. And for inspiration; anything from historical periods, from science-fiction/fantasy, from imagination is fair inspiration for creative designers.

One can imagine periodic fashion shows in Luna City, perhaps in a lee-vac arena, where models with very imperfect physiques, both male and female, would strut down a runway before onlookers behind glass observa-tion areas, with a variety of materials, colors and designs. Over a skinsuit, of course! Whether stylish, fanciful, sheer fun, what does it matter? Skinsuit outerwear fashions will say "we belong here, out on the moonscapes!"

This may become an anticipated periodic event even for those not anticipating lee-vac or out-vac excursions. With successive shows, and over the years, skinsuit "outerwear" items available in Luna City retail shops will grow in number, design variety, and sophistication.

Start of a Cottage Industry

Periodic fashion shows should be popular, and drive a startup cottage outerwear fashions industry. Over time, more and more pioneers, whatever their physique, will feel encouraged to explore what the out-vac and lee-vac environments have to offer. And for those venturing out, the great variety of outerwear fashions would make emergency identification easier, and people watching that much more fun.

Skinsuit outerwear and new performing arts

Lee-vac activities would become more varied as well. Can you imagine ballet not only in one-sixth G, but in vacuum as well? Lee-vac arena sports team uniforms would be more interesting and fanciful as well – all part of team sports enjoyment.

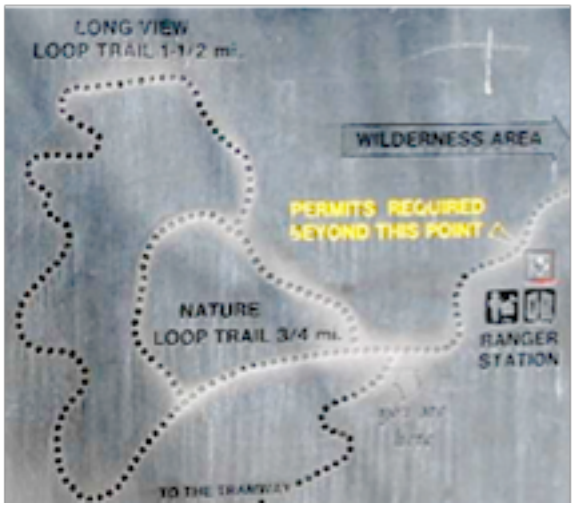
Beyond the protection of "lee" space

But these "fashion" developments might also encourage more and more lunar residents to wear skin-suits with outerwear even in full out-vac, the unprotected "vac"uum "out" on the lunar surface. Such sorties would be less risky during the "moderate risk" conditions of "early morning" days and "late evening" long shadow days. Remember it is not quite 15 days from lunar sunrise to sunset! Temperatures will be lower, but not the radiation level.

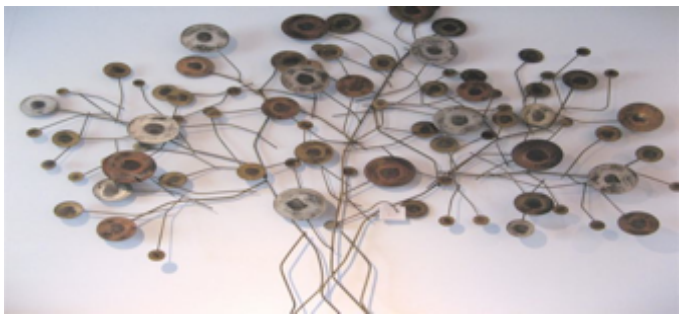
Another "low risk" opportunity lies during the1-3 hour long solar eclipses when the surface of the Moon is lit with the ruddy light of the ring of sunrises and sunsets that circle Earth when Earth itself is blocked out as the sun slips behind it. (An event paired with total lunar eclipses seen on Earth.) During such periods, the out-vac will take on the appearance of marsscapes in twilight!

Surface paths and trails for strolling

But before such surface recreational strolls can become popular there needs to be some encouragement in the form of "excuses to venture out:" something worth going out on the surface to see and experience. Most people will not just wander out on trackless wastes just for the sake of doing so, at least not often! But Luna City Fathers can encourage people to get out from the confines of the settlement encouraging the creation of "nature" paths that showcase local geological features of interest. Compacted and sintered, these paths will be relatively dust free yet allow enjoyment of the "natural" moonscapes to either side. Such a path could encircle the settlement, with bridges and underpasses where the path intersects roads into and out of the settlement. After sundown, rocks and cut breccias selected for phosphorescence could trace the way.



Art and Sculpture along the way Sculptures of an ever more varied variety and originality along such paths could also attract exo-pedestrians. In turn, the opportunity to have their works seen and admired by many will encourage artists and sculptors to create objects of interest and fascination



Fanciful metal sculpture "moon shrub?" Free scrap metal is manna from heaven for sculptors

. There could also be benches, each of a unique design (how about a pioneer design competition to stir extra interest?) and an objet d'art in itself would encourage walkers to take a rest, the better to appreciate the art and views along the way.

Animated Sculpture

On Earth, mobile sculptures are powered by the wind or sun. On the Moon, the solar wind blows at hundreds of miles per second, but is too thin and lacks the oomph to power anything. What about solar power? Solar panels could easily drive small motors and actuators to create mobile sculptures on moonscape paths and trails frequented by walkers after sunrise and before sundown. They'd work during high noon, of course, but few people would venture out on the trails at those times.

Let's use our imagination! Solar powered animatronic guides to explain landscape, rock, and geological features? Even programmed to answer routine questions? {"Where is the nearest restroom?" "Are there any vending machines nearby?"). Why not fanciful alien creatures that would leap out from behind a boulder to scare and delight children? Halloween when it occurs near local sunset could become a trail-event must!

The oldest, easiest hobby?

But perhaps the most interesting things to observe and study will be provided by the walkers themselves. They will no doubt appreciate this special opportunity to partake in the perhaps humanity's oldest hobby: going somewhere just to see and be seen – people watching! "Oh look at what she's wearing!" "If he thinks we can't see that he has a potbelly, he's fooling himself."

Bringing the Lunar Frontier to life while preventing neurosis and psychosis

Is all this idle diversion? What has all this got to do with anything? Getting pioneers to venture outside the pressure hulls of their settlement is absolutely vital to the long term mental health not just of individuals, but of future lunar frontier society in general. We on Earth see the lunar surface as hostile, barren, life squelching, and some thing to be avoided at all costs. To tell the truth, those of us who see it that way are poor settler material.

It is imperative that the pioneers learn to make themselves feel "at home" on the Moon not just within their comfortable settlement homes and common spaces, but out on the surface as well.

The penalty of not doing so will be neurosis and psychosis not just of individuals, but very likely of lunar frontier society in general. If we are going to make ourselves at home, we must do it in a "no holds barred" fashion.

- Life-squelching cosmic rays and solar flares?
- Tissue-burning ultra-violet?
- The incessant micrometeorite rain?
- The insidious, potentially poisonous moondust?

A lesson I learned from my mother is that "every apparent disadvantage remains so as long as we are looking at it wrong." "Change your attitude and try to see how that feature can be turned into an opportunity!" Then you will see it in its true light for the first time!

` Not a common attitude to be sure, but try it! It works. Now that's the stuff of which those pioneers who will survive and strive will be made of. Attitude is everything, and the naysayer, the timid, the "Oh, we can't …" crowd just doesn't get it, doesn't understand, and we have to ignore them and move on. The Lunar Frontier is our dream not theirs, and it is ours to pursue. The above attitude works on everything: from apparent life setbacks to obstacles on the road to the Moon and beyond.

Beyond the visions of "fellow travelers"

Some "pro-space" writers want to see robots do everything. "There is no need to put humans in such alien and hostile and god-forsaken places," they advise. But they have it all wrong. Venturing into new turf, into spaces that at fist seem hostile to human life, is something we have been doing even before leaving our home world in Africa to settle the rain forest jungles and the parched deserts of the first human continent, in a journey that would someday see us settle the north arctic which would have seemed as life-squelching to an early African in what is now Kenya, as life on the Moon must now seems to many of us incapable of getting past intimidating first impressions.

We have got to where we now find ourselves, a truly global species, by venturing into one new land after the other, where the wildlife, the vegetation, the climate, and the available resources were different from where we came from, from what we were used to and had taken for granted. And guess what? Each time we learned to make ourselves at home. Each time we learned to live with the "dangers" and "challenges" posed by the new territory.

From a more meta-historical vantage point, each time we developed ever more of our amazingly adaptive unsuspected human potential. Each time we realized more hidden human talents. Each time we brought out more of the potential that gives glory to the creative agency or agencies that have driven us and drawn us forward and upward.

Why would some put a cap on what we humans can do? A cap based on past accomplishments in Africa 200,000 years ago would have been quite immature. A cap based on our accomplishments to date in the early 21st Century would be just as pre-mature. Our fellow travelers, those who would see robots explore space and access its resources but leave humans at home, are just that. Fellow travelers. We can use their limited support, but we must never accept the limits of their vision.

So you thought that this would be just a "far out" article on whimsical spacesuit outerwear fashion! Everything bears on everything else. Where we are and where we will be in the future is a web of endlessly varied possibilities. Let the adventure never end!

The Moon, its capacity to support a full flowering of human life quite unsuspected, will be the first of many new worlds. Why should this surprise anyone. Every element in our bodies, and in everything we see around us, other than hydrogen which is primordial, originated in the furnaces of star core explosions.

"Of stardust thou art And to the Stars thou shalt return"

Now that is a "pilgrimage", a "directive", that will take us centuries, millennia, maybe eons to pursue. We are at the "baby's first steps" stage, the most critical of all. We have yet to truly integrate Antarctica into our human metaworld, and timidity, self-doubt, and endless diversions threaten to stifle our next frontier-exploring efforts. Are humans up to the challenge? Despite every thing that should give us pause, a look at our past should encourage us. We have always taken that next step and we

have always succeeded. Now is certainly not the time to doubt either our own capacities our our destiny.

But each time, only a few pioneer the new “world” and they do so despite the discouragement and disinterest of the many who remain behind. <**MMM**

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“Native Lunan” Arts & Crafts are essential for Pioneers to feel truly “at home.”

For they will arise from lunar materials and lunar conditions. This will include performing arts such as dance forms and gymnastics and sports as well as many indoor and out-vac hobbies and activities.

Native Arts & Crafts and finishings will mark frontier homes and living spaces as truly Moon-derived , Moon-expressive, and Moon-respecting.

It is through locally derived Arts & Crafts materials and media that we have come to “belong” in one frontier after another in our long epic “Out of Africa” intercontinental spread, and how we will do likewise as that Epic begins to test the Interplanetary space. **MMM**