Papers on the Lunar Settlement

Engineering 2 : Illumination

0. Necessity As Luna City will be situated underground, and in any case the Lunar surface is in darkness for 350 hours at a stretch, plentiful artificial light will be required, both for human vision and for life-support uses such as plant growth.

1. Sources The use of conventional individual electric lamps is contraindicated by the unavailability of significant supplies of tungsten and mercury in the Lunar environment. Light-metal vapour and inert gasses, as well as electroluminescent materials, may be turned to this purpose, but they tend to have characteristics which limit their application.

Accordingly, it appears that the proper course will be to employ large central lamps, such as arc lamps or RF-excited sulphur lamps. The latter, with their molecular emission spectrum, are particularly attractive if supplies of sulphur can be provided from gas drilling.

2. Distribution While high-intensity lamps can be applied in large public spaces using nothing more than appropriate diffusers, in smaller enclosed spaces both the location and the intensity of illumination must be controlled. Accordingly, some system of directing the light from a single source to multiple points and controlling its intensity at each point must be devised.

The most obvious means of distributing light from a central source is by means of light guides operating on the principle of total internal reflection, such as flexible optical fibres and rigid light pipes. The area served by any one lamp in this case will be limited by the transparency of the optical material, based on the diminution of light available at the end of the guide, as well as the loss of light to waste heat.

A simple arrangement would involve individual light guides running from the central lamp to outlets, each provided with a mechanical damper such as an iris diaphragm or a variable-density filter wheel. This type of plan, however, has large requirements for materials and installation work, and does not provide any clear method of redistributing light according to demand. A superior system would permit several outlets to be served from a single light guide, in such a way that the light not wanted at one point would be available at the others.

3. Specifics and Implementation
The physics of total internal reflection suggest that this goal can be achieved. This phenomenon occurs at the boundary between two transparent materials having different refractive indices, such that the deflection angle according to Snell's law is sufficient to direct the ray back into the body it was leaving. This indicates that light can be transferred into and out of a TIR light guide where the core contacts a body having its own refractive index. In the illumination application, of course, time-coherency of packets is irrelevant, a broad cone of acceptance is desirable, and angular dispersion can be neglected in design, with the result that air-clad guides may be used freely.

Accordingly, a single light guide can be used to serve multiple outlets if taps can be placed along its length, and it would appear that such a tap may be as simple as a piece of the same glass as the light guide, pressed against the guide in close contact. In order to increase the intimacy of this contact, a thin film of some fluid (such as silicone oil) having a similar refractive index may be introduced between the two surfaces – anyone who has set a wet drinking-glass down on a glass tabletop will understand immediately.

If the contact area of the tap can be varied, the amount of light released at the tap will vary in proportion, and the second objective can be attained. For example, if a branch of the light guide consists of a flexible air-clad fibre, a tap can be arranged in the form of a short glass cylinder with its axis perpendicular to the fibre axis, and one end silvered. When the cylinder does not touch the fibre, no light is transferred between the two bodies. When light is wanted, the cylinder can be made to touch the fibre, and at the point of contact some light will pass into the tap, and be emitted from the transparent end. When more light is wanted, the cylinder can be pressed harder against the fibre, which will wrap somewhat around the curve of the surface, increasing the contact area and thus the light transferred.

For larger light demands, variations on this system can be proposed, involving multiple parallel fibre guides, a fibre tap against a rigid guide, a rigid tap pressing against a rigid guide with variable pressure to vary the area of the contact patch, or other arrangements to accomplish the same end. Since the light transmitted to the end of the guide will be in inverse proportion to the light drawn off at the taps, a photocell at this point may be used to vary the output of the light source according to aggregate demand, thus rationing energy.

4. Conclusion A sketch of the production and distribution of light at Luna City has been given. A method for bulk transmission of light from central sources, with control of local emission, has been proposed. It may be noted that the same light distribution network will permit use of sunlight when available.

revision 0
submitted for consideration by ***publius***
2007-120