The Hopes of Postwar Light Sources

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IN THE research laboratories of Westinghouse there are among many of the problems receiving constant attention the very vital ones of transferring electrical energy directly to radiant energy without the intermediate step of heat. The objective is old, but several recent approaches are new. When this war began, some 95 per cent of the man-made light sources were tungsten filament lamps having their optimum economic light emission when the filaments were operated at a temperature of approximately 3000° K., and whereof the heat losses were on the order of 90 per cent of the input energy. This did not seem good enough.

The commercial Mazda filament lamp with its efficiency of some 14 lumens per watt where 7.5 per cent of the input energy is converted into radiation to which the human retina responds, may well remain a standard article for household use and for small-wattage local industrial lighting equipment, but the urge for interior large-scale lighting and for illumination levels on the order of 50 to 100 footcandles demand that higher efficiencies be attained. How high are our hopes?

Romantically, the scientist turns again to studies of the firefly, of luminescent bacteria, and of chemiluminescence or bioluminescence in Nature. It is roughly estimated that 90 per cent of the radiant emission from a firefly is luminous, closely approaching 500 lumens per watt. This is 10 times the ultimate efficiency that could be expected from a tungsten filament lamp since tungsten when melting at about 3655° K. could generate visible light at no better than 55 lumens per watt. If such a lamp were to burn for several hours, an efficiency of 35 lumens per watt would more correctly represent a practical top limit.

Like the firefly, most of Nature's lamps produce light by oxidation. No energy whatever is wasted in the production of invisible ultraviolet light and practically none in heat radiations. Man's latest lamps willy nilly generate much of both.

It appears that Nature's illuminants developed simultaneously with Nature's seeing organs. The luminous emission from a typical insect like the firefly is confined to a very narrow band of wave lengths, concentrated at the central point of the visible spectrum or at the light yellow-green color region (5700 A. U.) where the response of the retinal nerves is most sensitive. Little or nothing is lost in emitting red or blue colors. By contrast, man's illuminants, particularly those of the hot body or incandescent types emit a great deal of light at the long wave and also the short wave ends of the visible spectrum and it is this radiation which, in addition to the infrared and ultraviolet, is generally wasted so far as seeing is concerned.

From a study of the color response characteristics of the human retina we might conclude that the sodium vapor lamp for instance which concentrates practically all of its luminous output at a wave length of 5890 A. U. (lemon yellow) would be the best light source for general purpose seeing. However, a study of this and other almost monochromatic lamps indicates one further difference between Nature's illuminants and man's. The purpose of the latter is to make surrounding objects visible by light reflection therefrom, whereas Nature's lamps are primarily to be seen as signals, or markers, or lures. Man's seeing judgment depends to a large extent upon the color of the object being viewed and hence a monochromatic source with its resultant distortion of object color fails to meet our broad criteria for the ideal illuminant of tomorrow.

When we employ the energy of electricity to displace or excite the outermost electrons of the mercury atom within the commercial tubular fluorescent lamp thereby generating short wave ultraviolet radiations, and when this radiation in turn upsets the normal atomic arrangement of the phosphor crystals coated on the inside of the glass tube, we have achieved a "short-circuiting" light-making process—*i. e.*, we eliminate the production of much heat. By this method some 18 to 20 per cent of the input energy is converted to usable light. This still seems not good enough.

An arc discharge through high pressure mercury vapor ranging from 1 to perhaps 80 atmospheres (but commercially at about 3 to 5) develops luminous radiation at a commercial efficiency on the order of 65 lumens per watt. This is better—and further research will increase this efficiency in proportion as we can increase the temperature and pressure of the mercury vapor. The problem here is the refractory characteristic of the container. Summing up the situation we then have this analysis:

1. Tungsten filament illuminants now developing some 15 lumens per watt and practically limited to 35 or to a theoretical and ultimate maximum 55.
2. The fluorescent lamp, now developing some 45 to 60 lumens per watt and capable of doing roughly twice as well, as the technique of developing 2537 A. U. ultraviolet from mercury vapor and of efficiently exciting phosphor crystals therewith is perfected.
3. High-pressure metallic vapor discharge lamps now producing 55 to 70 lumens per watt and theoretically capable of going considerably higher in efficiency if refractory containers could be had so as to permit increases in temperature that accompany pressure beyond roughly 5 atmospheres.

These, then, are some of the present day problems in lighting research that seem to offer a challenge to the engineer who recognizes that postwar lighting requirements will demand vastly more artificial illumination than man has heretofore enjoyed.