THE COOPER HEWITT LIGHT-TRANSFORMING REFLECTOR.

BY JOSEPH B. BAKER

The analysis of ordinary daylight given by its spectrum shows that it consists of a commingling of all visible wave lengths of light, from the longest waves at the red end of the spectrum to the shortest waves at the violet end.*

The spectrum shows the distribution of these wave lengths and the amount and the intensity of light in each. Colored bodies give the impression of color on account of the property of reflecting to the eye certain wave lengths and absorbing others. If the light illuminating the object is intense in the particular color reflected by the body, then the body will appear very brilliant, but if the light is deficient or weak in the wave length representing this particular color, the color of the body will be weak or not visible (there being little or no light that it can reflect to the eye) and the body will appear dull or black.

There are a number of artificial lights which are brilliant and economical, but lacking in "quality," or color values for certain purposes for which they may be used, and also as compared with daylight. Whether the means of producing these lights is oil, gas, or electricity, one and all are at a disadvantage in that their spectra differ in range and distribution of wave lengths from the solar spectrum, so that fabrics have a different color when viewed by each of them; and some are more or less displeasing to the eye, or unsuitable to work by, especially in occupations requiring close application of the eyesight.

From time immemorial attempts have been made to "soften" the light coming from artificial sources—as, indeed, daylight also—by the use of colored shades, which cut down the intensity of light in certain portions of the spectrum. But these attempts result in inefficiency, for the reason that a light-transmitting shade cannot color the light which shines through it, but can only transmit certain of the wave lengths already in the light, suppressing the others. Thus a red-tinted glass shade surrounding a powerful light source rich in green rays will temper the disagreeable glare, but will also enormously cut down the total amount of light from the lamp, by straining out nearly all wave lengths except those in the narrow range in the red and the blue regions of the spectrum; the shade not being able to put into the emitted light what is not there already. It would be desirable, but it has hitherto been impossible, to apply a shade or a reflector to a light source which will have the effect of introducing into the light emitted by the lamp the rays in which the light source itself is deficient. A shade or reflector which would accomplish this result would become an important auxiliary to that light source, co-operating with the latter to give a satisfactory illumination from the lamp as a whole.

This result has been accomplished, it is claimed, in the new light-transforming reflector recently patented by Dr. Peter Cooper Hewitt, the well-known inventor of the mercury-vapor lamp. By utilizing the phenomenon of fluorescence Dr. Hewitt has succeeded in transforming the radiation of a light source which is powerful, but is considered deficient or of impoverished and ill-balanced spectrum, into radiation of a wholly different range of wave lengths, which eke out, so to speak, the distribution of wave lengths emitted by the source; the radiant energy being transformed or converted by the molecular mechanism of fluorescent material formed into a reflector for the primary light source. The fluorescence of the material being excited by the light from the source, the material emits its own particular colors, or wave lengths of light due to its fluorescence, which wave lengths, mixed with the original light, supplement the deficiencies of the last.

In order to understand the *modus operandi* of this

invention, it is necessary to define true fluorescence, as distinguished from the mere transformation of light into heat. The conversion of light rays of all the visible wave lengths into invisible heat rays is a well-known phenomenon, exemplified when light falls on a coating of lampblack or on a piece of black cloth, and which is car-

Application of light-transforming reflector to Cooper Hewitt tube and incandescent lamp.

DR. PETER COOPER HEWITT.

This photograph was made by the Cooper-Hewitt light.

ried to the theoretical limit in the "blackbody" of the physics textbooks. But when the light falls on a fluorescent body, inasmuch as the radiations from this body are in the visible region, for the purposes of this description the body may be said to be fluorescent.

The transformation of radiant energy into invisible radiations, or heat, is of no use for illumination purposes. But fluorescence, which is the action of certain optically active substances, in receiving radiations of a given range of wave lengths and transforming them into another set of wave lengths that are visible, is useful for illumination; and it is this property which Dr. Hewitt has conceived of as a means for transforming light from one color into another, and which he has utilized for this purpose in his light-transforming reflector. This light transformer, described in a recent British patent,* consists of a reflecting surface, such as kalsomine, giving light scattering or diffused reflection (as distinguished from the image reflection given by a polished glass or metal surface), coated with a layer of translucent material containing a fluorescent substance. This reflector is placed back of the primary light source—which may be, for example, a Welsbach incandescent gas mantle, a carbon or tungsten fila-

ment electric lamp, or a Cooper Hewitt tube—so that the radiation from the primary source impinges upon the reflector, and is by the latter given back in transformed condition. A considerable amount of the energy of the emitted waves is transformed, in passing through the fluorescent substance to the light-scattering reflecting surface, into a set of waves of a range lower down in the spectrum band—that is, in the red and orange region of the same—and in passing out again from this surface through the fluorescent substance, an additional amount of the energy is thus transformed. The total action of the reflector is therefore to transform a considerable portion of the original emitted energy from the light source into red or orange light. The reflector does not interfere with the rays coming directly from the light source, but the illumination as a whole, coming from the light source and the reflector, is made to possess a spectrum of far better distribution than that possessed by the light source alone or by the same equipped with an ordinary non-fluorescent shade or reflector, and the illumination from a Cooper Hewitt lamp may be made to compare favorably with daylight.

A striking example of this general achievement of Dr. Hewitt is the application of the light-transforming reflector to his own lamp. It is well known that this lamp emits a greenish light which is almost wholly lacking in red rays, and which is therefore not adapted for general illumination, although admirable for certain special uses, such as photography and photo-engraving, on account of the richness of the light in blue and in violet, and for drawing offices, machine shops, and certain other work rooms. The spectrum of the Cooper Hewitt light embraces, roughly, the upper half of the solar spectrum, although with markedly different allotment of bands and lines which result in a preponderance of green, so that many objects illuminated by the tube show certain colors as different from those familiar to their daylight aspect. Certain shades of blue become purple, and human faces look either very dark or ghastly pale, according to the amount of ruddy "color" in the complexion. Such are the nature and the limitations of the Cooper-Hewitt light, which have barred it from general utilization as a social illuminant, notwithstanding its high electrical efficiency, simplicity, and economy.

Now place behind the mercury tube a concave, trough-like fluorescent reflector, consisting of a white reflecting surface coated with a translucent film impregnated with "rhodamine B." The illumination is transformed, as by magic, to a close approximation to daylight, and objects and fabrics, such as wood and metal articles, colored chemical solutions, silk ribbons, woolen rugs and hangings, resume their normal or familiar colors, and the faces of friends clear to the "natural hue of health." In the laboratory of Dr. Hewitt, in the Madison Square Tower, New York city, the artificial daylight given by tubes equipped with his light transformer shows the natural colors of a card of silk samples at night as perfectly as the broad daylight coming in at a large north window when its shade is raised. No less striking is the appearance of the reflector and tube themselves, when viewed directly; the value of the reflector being evinced by the large proportion of the total light which it is observed to emit. The ocular impression of the fluorescent reflector itself as a true secondary light source, by reason of its activity as a genuine transformer of radiant energy, is strong.

The results to be expected are little short of revolutionary in the art of illumination, since by the use of the fluorescent reflector light sources which are not now commercially practicable may be brought into satisfactory utilization with no alteration of the lamp mechanism or mounting other than the attachment of the reflector, and no change in the electrical or other supply. It is conceivable that the cost of special color lighting may in future be materially reduced by employing primary light sources of high radiation efficiency but ill-balanced spectra, and then equipping them with light-transforming reflectors.

* By "daylight" is meant the best state of solar illumination, the most acceptable stage of the widely varying light of the sun between dawn and dusk and through all conditions of clearness of the atmosphere. It is, however, more than an open question whether daylight is the best illumination for certain classes of work, although it may be always the standard for color values. It is recognized by all women that daylight is by no means the most becoming light—candle light, and the light from a wood fire, which are much richer in red and orange rays, being preferred.

* No. 8,449, dated July 28th, 1910.