# Light for the Colorist

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In an earlier* issue of The Melliand we discussed the two scientific methods of expressing the color of light; one, by the use of a temperature scale, and the other, by means of a curve plotted from wave length and intensity. The former method is applicable only to light produced by incandescence, and to sunlight. The temperatures designating the color of light from the sources in common use are as follows:

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| Extremely clear northwest sky | 25,000°K |
| Blue northwest sky | 19,000° |
| Blue sky | 10,000° to 14,200° |
| Blue sky with thin white clouds | 13,400° |
| Uniform overcast sky | 6,000° to 7,000° |
| Average noon sunlight at Washington | 5,300° |
| Mazda C lamp in blue bulb | 3,600° |
| Mazda C lamp (12.6 lumens per watt) | 2,800° |

Average noon sunlight, or 5,300°, is usually taken as the standard for white light, and 2,800°, which represents a 100-watt Mazda C lamp, run at practically 13 lumens per watt, may be considered the standard for electric light as found in ordinary illumination.

How to convert standard electric light into standard white light is a problem that has engaged the efforts of many workers in the science of illumination. Raising the temperature of the incandescent body increases the intensity of the short wave end of the spectrum relative to the long wave end. The problem of moving up the color temperature of electric light is, therefore, a matter of increasing the blue and violet relatively to the yellow, orange and red.

## Popular Misconceptions

There is no way of adding to the intensity of any particular rays after they have been produced, although a surprisingly large number of generally well informed people have an idea that placing a piece of colored glass over a light-source adds that color to the transmitted light. I have been asked many times by technically trained men why the color of mercury light could not be whitened by putting a red glass over the tube of the lamp.

Since the color of light depends upon the *relative* amounts of the primary color-rays, it is possible to change the color of composite light by passing it through glass that will filter out a certain amount of a given color or colors, thus changing the relative proportions of color-rays. This is a familiar enough fact to color technicians. Passing electric light through blue glass reduces the yellow, orange, and red rays in proportion to the blue and violet, and so moves up the color temperature; that is, whitens the light.

The quality of the whitening, and the equivalent increase in color temperature, produced by the various commercial light-units designed for the purpose, are matters not so well understood. In fact, there has been much misunderstanding on these matters as a result of the claims set forth by the makers of such units.

Nothing is easier in glass manufacture than to make blue glass, of any degree of density. Cobalt gives a clear ultramarine blue, and cupric oxide a fine turquoise; while amethyst hues are produced by manganese. The cheapest forms of glass can thus be colored without adding sensibly to the cost of production. The temptation to equip lighting units with accessories made of such glass, and to make up the selling price in proportion to the claims for them, is too great for some dealers to resist. The amazing ignorance and credulity prevalent in regard to the technology of light and vision adds further to the temptation. When a light unit is said by its sponsors to produce an illumination "like daylight," or "the white light that the artist demands," or "by which colors can be matched perfectly," the statements must be taken with reservations until the actual color temperature of the light can be determined.

## Obstacles to Raising Color Temperature of Light of Ordinary Lamps

There are insuperable physical and physiological obstacles in the way of raising the color temperature of the light of ordinary electric lamps. The physical obstacle is the fact that such light has a very small content of the blue and violet rays. The physiological obstacle is the fact that the yellow rays, and those near them in the spectrum, are enormously more effective in producing the visual sensation of light, or brightness, than the blue and violet. Both of these facts work against the efficiency of the only possible method of raising the color temperature of the light after it is produced; that is, by the use of color filters.

The net result of this combination of adverse conditions is, that at least 80% of the total light must be

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absorbed in order to raise the color temperature to that of standard white at 5,300°K; in other words, only one-fifth of the light produced is available as true white light. Since absorption of light means conversion into heat, it follows that five times as much heat is produced for a given amount of illumination, which may constitute a serious problem in cases where a considerable quantity of light is required, together with a high intensity of illumination.

It is obvious that some means of producing white light with less waste of the light generated is highly desirable. This presents another temptation to the maker of lighting equipment, namely, to claim a higher efficiency than that of competing devices. The conditions, however, are as fixed as the law of gravitation, so that all claims for an efficiency over 20% in the production of standard white light are evidence that the light actually produced is of lower color temperature and, therefore, not true white.

## Characteristics of Lenses

To the average user of light a lens is a mysterious contrivance for manipulating light in all sorts of uncanny ways. This mysterious action of lenses is also exploited by some makers of units for producing alleged white light. As a matter of fact, they do not use lenses, but curved glass placques. The essential characteristic of a lens is a difference in thickness between the center and the edge. A circle of sheet glass given a spherical curvature does not constitute a lens. Since the absorption of colored glass depends upon its thickness, it is obvious that a lens is absolutely unsuited to the production of white light for purposes of illumination, as it would not give a uniformly colored field.

In order to raise the color temperature of electric light by the use of colored filters without distorting the spectral composition, the hue of the filter and the total absorption must be accurately adjusted. The absorption can be regulated with a high degree of accuracy by varying the thickness of the glass. The production of the correct hue requires careful adjustment of the coloring matters in the composition of the glass.

Filters in which both of these variables have been determined with great accuracy have been worked out and commercially produced by the leading maker of technical glassware in this country, and utilized in several types of units designed to meet the requirements of color technicians. These units are commercially available, and can be depended upon to perform as claimed. One type of unit is designed so as to illuminate the field with either white light or average electric light by the throwing of a switch. This is an essential facility where colors must be matched or examined under both qualities of light, as is the case in the textile industries.

For the inspection of small colored surfaces for the purpose of color matching, or similar observation, a single unit of this kind gives a sufficiently large field of white light, which is invariable within the average limits of visual discrimination, so long as it is properly maintained.

The colorist may be either a color technician, responsible for the production of the colors of goods; or an artist, responsible for the combinations of color used in the design or decoration of objects. The accurate matching of colors has been, and still is an important function of the technical colorist. The importance of this function, however, may be materially altered by the advent of instrumental means of color matching which are independent of the human eye, and within certain limits, of the color of the light.

The lighting conditions required by the color artist are different in one important respect; he requires illumination over a relatively large field, often throughout a moderate size room. While it is quite possible to produce artificial white light to this extent, the artist will probably continue to depend upon daylight as a general rule.

As previously pointed out, all colors appear lighter as the intensity of the light increases. In one case within my knowledge, in which furniture is decorated by hand painting, the decorators were able to do their work satisfactorily when a high intensity of illumination was produced by the regular Mazda C lamp. This is a matter in which further investigation would doubtless yield interesting results.