from his society, well explained by the above weather and creative characteristics, so different from the inapplicable but nevertheless insistent standards taken from the past and used for the present, apparently reached its peak in 1900. The gap now should be lessening, and probably is. In the United States[10] the art has been neither as extreme nor as rejected as in Europe. It is time that our country should come of age culturally. With our origin as a nation in the colddry 1780, and our major inheritance from the colddry period of 1830 to 1870, it is probable that our own great American art, possibly even to be recognized, will occur comparatively soon. Actually, between the coldwet confusion of today, and the colddry peak of 1965, there will probably be a temporary phase of warmwet hope.

LIGHTING AS AN INTEGRAL PART OF ARCHITECTURE*

Richard Kelly

A FEELING for light and lighting starts with visual imagination, just as a painter's talent does. Think of the creation of a watercolor rendering—First, major highlights are imagined—then, graded washes of different luminosity are added and—then, the detail of minor lightplay makes the idea clear and entertains the eye.

In front of the mind's eye are three elements in the perceptions of visual design—three elemental kinds of light effect which can be related to the art of painting for easier visualization: (1) Focal glow or highlight. (2) Ambient luminescence or graded washes. (3) Play of brilliants or sharp detail. These three elements are also the order of imaginative planning.

[10] Again the honest historian can only compare the recent Europeanization of our art with the French Impressionism of Twachtman. Foreign to our soil it was at first greatly admired as "modern," but the many museums which squandered their money on his art are now generally taking his pictures off their walls. Inness was the American representative of this style, although he correctly insisted that he was not an Impressionist; Twachtman was only an imitator. Who is the American Picasso, not following in his footsteps but paralleling his development?

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Focal glow is the campfire of all time. It is also the celebrated limelight of aphorisms because the early English music halls used antiquated projectors which burned a gas resulting from wetting a kind of lime (now commonly known as "carbide"). Focal glow is the follow spot on the modern stage. It is the pool of light at your favorite reading chair. It is the shaft of sunshine that warms the end of the valley. It is candlelight on the face, and a flashlight on a stair.

Focal glow draws attention, pulls together diverse parts, sells merchandise, separates the important from the unimportant, helps people see. Focal glow sometimes becomes multiple foci desirably producing a significant composition of attention. As the number of foci increase to more and more complex compositions, a pattern results which can resemble the second basic element of light—

Ambient luminescence is the uninterrupted light of a snowy morning in the open country. It is foglight at sea in a small boat, it is twilight haze on a wide river where shore and water and sky are indistinguishable. It is the before-the-show lighted dome and amphitheatre of the Hayden Planetarium, the full cyclorama of the open theatre. It is any art gallery with strip-lighted walls, translucent ceiling, and white floor. It is also all we know of "indirect" lighting.

Ambient luminescence produces shadowless illumination. It minimizes form and bulk. It minimizes the importance of all things and people. It suggests the freedom of space and can suggest infinity. It is usually reassuring. It quiets the nerves and is restful.

Play of brilliants is Times Square at night. It is the eighteenth century ballroom of crystal chandeliers and many candle flames. It is sunlight on a fountain, or a rippling brook. It is a cache of diamonds in an opened cave. It is the rose window of Chartres. Night automobiles at a busy cloverleaf, a night city from the air. It is the trees outside your window interlaced with the beams of spotlights. It is a sparkling cabinet of fine glassware.

Play of brilliants excites the optic nerves, and in turn stimulates the body and spirit, quickens the appetite, awakens curiosity, sharpens the wit. It is distracting or entertaining.

Visual beauty is perceived by an interplay of all three kinds of light, though one is usually dominant. It is, therefore, of first importance to plan lighting, whether you are creating a new structure to interpret an idea of house and home, whether you are altering an old structure to meet new needs, or whether you are making-do with existing conditions as an interim in someone's longer term program. By the judicious and artful control of these three distinct

elements in lighting, you can make the imagined watercolor rendering become the real thing, beauty of architecture and decoration. These three kinds of light, (1) Focal glow, (2) Ambient luminescence, (3) Play of brilliants, respectively (1) make it easier to see (2) make surroundings safe and reassuring and (3) stimulate the spirit.

The trained eyes of the impressionist painters have helped our eyes to see the real appearance of material as revealed by many contrasting kinds of light. Note Monet's series of eight or nine paintings of Chartres Cathedral describing a full range of appearance from strong sunlight to twilight.

Psychologists have substantiated the theories of modern metaphysicians such as George Berkeley, through Whitehead and Santayana, to Einstein. They say our real knowledge of the concrete world and all materials is *based* on sense perception, not on abstract learning. Yale's motto "Lux et Veritas" old at adoption, now has new light and real truth. There is a new dependency between light and truth behind contemporary perception.

Psychological experiments have been even more detailed. The American Foundation for the Blind, working for people who do not take light for granted, in the annual report for 1948 says that 87% of all human perceptions come through our eyes. Architectural design and decoration is created to serve mankind by bettering the sensual perceptions of life. Thus the purposeful and accidental action of light in creating visual perception determines seven-eighths of the total impact of architectural and decorating work.

Le Corbusier's definition is *"L'Architecture est le Jeux, savant, correct, et magnifique des formes sur la lumiere."* ("Architecture is the play, knowing, correct, and magnificent of form in light)."

These new thoughts might seem fascinating intellectual by-play, except for very important coincidental phenomena.

The last two decades have developed by invention and production more new sources of artificial light, its control equipment, and more knowledge of daylight and its control equipment than were developed in the preceding two millennia (our known technical history).

Nine out of ten of the artificial light sources, fixtures, and equipment specified and used today did not exist twenty-five years ago. For example:

(a) The sealed beam lamp, the mushroom shaped bulb of mushroom growth.
(b) The maligned but useful fluorescent tube that is changing its colors and becoming friendly.
(c) The "slimline" fluorescent of longer, convenient lengths that can be installed at a choice of intensities.
(d) The cold cathode fluorescent that can be shaped to almost any delineation.
(e) The new mercury vapor lamps of high efficiency and spectrum, helpful and

flattering to green plant-life, especially outside glass houses and even picture windows when we want to seem to bring the outdoors indoors.

(f) The beginning of a two dimensional panel light source now available for small areas in limited intensities and colors will lead to more important uses.

(g) The production of accurate molded lenses suitable for permanent installation at reasonable initial and maintained cost.

(h) The substitution of efficient metal reflectors for glass.

(i) Wonderful new candles, more light per ounce, less drip, long burning, insect repellent, perfumed, fire kindling, etc.

(j) New kerosene sources, round hollow wicks, less soot, even some incandescent kerosene burners.

(k) New tanked gas for long burning firelight.

(l) New wiring methods, circuit breakers, panel control, contactors for remote switching.

(m) Low voltage wiring for miniature sources, and for almost invisible wiring for delicate designs.

(n) High voltage wiring to reduce maintenance of step-up transformers, etc., for some large fluorescent installations, or to reduce bulkiness of fixtures.

(o) Induction wiring in rare instances where complete elimination of wire to light source is very wanted.

(p) New transformer type dimming equipment (no heat or waste) both by dial knob or push-button remote control for constant adjustment of visual surroundings to changing numbers of people, and attitudes. Rate of light change can be geared, pre-set for automatic change, or made automatic through light cell control complementary to daylight or other artificial light change. Light can even be controlled by voice or by music.

(q) Ingenious mechanism is produced for raising and lowering light equipment, for moving it across a ceiling, for multiple or continuous plug-in attachments.

(r) Even the common garden-variety light bulb is entirely new, by too many inventions to enumerate now.

Daylighting equipment is less familiar to most laymen. Industry has spawned many of the most effective devices, such as:

(a) Calculated angle or curve of window glass to control reflection and visibility from either or both sides.

(b) Direction of light transmission controlled by louver glass, louver screen and polarized filters.

(c) Color transmission control for temperature and visual sense of temperature, from infra red to ultra violet.

(d) Calculation of daylight brightness by relation of indoor floor color and terrace floor color, to wall color and ceiling color, for composition of major daytime highlights.

(e) Diffusion of daylight by enlarged curtain areas of calculated brightness to provide indirect lighting by day.

(f) Multiple small skylight domes set up in dark cylinders or squares to control angle of overlapping downlights and eliminate glare in normal line of vision.

(g) Dark louvering of larger skylights to eliminate overhead glare.

(h) Use of strip skylights to wash walls with graded daylight.

(i) Careful concealment of daylight apertures with baffles and reflectors to daylight spotlight some important objects, and areas.

(j) Window sizes and shapes are now possible to classify for different room

uses. For example: The narrow horizontal window is good for shallow rooms only, because though it spreads light more evenly on ceiling and floor it often introduces bright glare by contrast at a distance from the window wall. Tall, narrow windows introduce better light deep within a room at useable angles with less glare by contrast.

(k) Vertical blinds can eliminate direct low angle western sun from conversational and work areas without eliminating high angle stimulating sunlight at earlier hours of the day. Sometimes these blinds can be automatically geared to turn with the sun putting sunlight where you want it.

(l) Horizontal baffles, both interior and exterior, and Venetian blinds can be made to do calculated tricks to daylight.

(m) In addition there is a whole bag of daylight trick devices: Light traps outside window; water reflectors; color adjustment by reflection from large areas of red brick or aqua glazed tile wall surfaces; color adjustment by filtering of a specific type of green leaf (vines or trees).

This overwhelming development of technical devices to create and control light should not confuse either lay users or their advisers. One wonderful device may be new, wonderful, and ideal for its special purpose, but this purpose may be very small in the whole range of living activities. These devices for producing and handling light are tools for working with the basic and still little known performance of light waves. However, light itself as a physical force can have specific qualities attributed to it by the regular occurrence of specific effects as does the wind.

Two qualities are best mentioned together—intensity and brightness. Intensity is the total quantity of light flux moving toward a surface. The light flux is usually measured in terms of numbers of U. S. Bureau of Standards sperm candles. The intensity arriving at any surface is then usually measured in terms of foot candles. Brightness is the apparent light per unit area reflected from or emitted through a surface or area. This is measured in lamberts.

The gradual production of stronger light sources has, through habit, actually made greater intensity of artificial light necessary for simple seeing and reading, just as new glasses make seeing without them more difficult than before the glasses were first used. Tested foot candles required for reading by artificial light have increased year by year for the past twenty years.

However, if the sun as the source of light is outside the normal field of vision, in sewing on very dark cloth with very dark surrounding surfaces it is possible to see comfortably with an intensity as high as ten thousand foot candles on the work, but with brightness as low as one to ten foot lamberts reflected from it.

On the other hand, in many older offices today work is sometimes attempted with an intensity as low as five or ten foot candles while numerous light sources such as exposed bulbs or bulbs enclosed in small glass globes are

unavoidably in the immediate field of vision, with a brightness of 200 to 500 foot lamberts.

As a general rule it is desirable to plan for high intensity in foot candles with low brightness in foot lamberts. This attitude has become perhaps the most important technical objective of planned lighting in architecture. With all our new tools of new sources and equipment the accident of high brightness (usually called glare) is almost inevitable except for very skillful planning. Even when the light source is a perfectly designed piece of modern equipment the newly possible high intensities may produce overly high brightness or glare because of the misplacement of white surfaces or specular surfaces, such as white and/or glass desk tops, or white floors with southerly unshaded glass walls. This is apt to happen in the older usual process of architectural design, which is the play of forms of various scale, proportion, material, color, and decoration—permanent and stable, *as abstract truths;* instead of with visual imagination as the *cause of visual experience in sense perception.*

A third quality of light is diffusion. Complete diffusion is best illustrated by an open white sandy beach on an over-all cloudy day. Degree of diffusion depends on the relative size of the light source. A very large source of diffused light produces no shadows because of multiple directions of incidence. A small or point source produces a sharp shadow. Undiffused light is called hard. It is sometimes desirable to excite the optic nerves—as in a dining room where crystal, silver, and porcelain all lighted by projected point sources exhibit qualities we have habitually called intrinsic to these materials. Usually even here it is necessary to provide the softening effect of diffusion by ambient luminescence for comfort.

Reading well for long periods requires diffused light to eliminate brightness of reflection from shiny paper and to eliminate hard black shadows which tire the eyes through constant refocusing.

The fourth quality of light is spectral color. Most physicists agree that color or predominance of one light wave length is registered by the eyes only relatively to other colors or other wave lengths. That is, if the eye is subjected to pure red light and no other light at all for even a fairly short time (as has been demonstrated in laboratory tests) the mind does not see red as usual, but only as light and dark values, as white, grey, and black. Seldom are we exposed to pure color but daylight varies in color from dawn to dusk, in various latitudes, and under various local climatic conditions from visual orange to deep blue. Most people do not consciously register this change because daylight is so all pervasive there is little differential reference. At high noon on a dry clear day daylight is nearest to so called white. Before sundown on a moist clear

day sunlight passes through the greatest distance of earth's atmosphere and the shorter wave lengths toward blue are partially refracted so that the resultant penetrating light is largely of longer wavelengths toward red. Human skin then looks best—the blood's healthy circulation is intensified. We can often *artificially* create a similar condition by filtering all the light sources which reach people slightly toward pink, so that there is no color reference, the light seems white but people look healthy and are thus actually happier.

After sundown all daylight reaching human beings is predominately heavy with refracted short wave lengths toward blue. At this time of twilight redder artificial light sources are often used in conjunction with waning daylight so that there *is* a color reference and most people are thus conscious of the blue color of twilight. *Artificially* we can also use a background bluish diffusion as a foil for warm pink highlights to glamorize human features and skintone, just like twilight with candles or firelight.

A fifth light quality is the direction of major apparent light areas relative to eyelevel. Predominant light areas above eyelevel produce a feeling of restraint which is usually called formal atmosphere. Predominant light areas below eyelevel induce a feeling of individual human importance which is usually called informal or cozy atmosphere. And, the sixth light quality is movement real and implied.

In the use of any and all knowledge of light, its qualities, its traditions in cultural influence, etc., in combining the three major elements of visual sensation to make beauty, remember that "Variety is the spice of light" and thus must be used cautiously by an understanding hand to be visually significant.

To play with light is to play with magic—it demands (1) a trained eye to recognize real and relative values (2) experience and knowledge of the cultural and psychological effects of light on people (3) experience and knowledge of physical techniques.

Lighting is both an art and a science. In 1917, Mr. Mathew Luckiesh of Nela Park wrote of lighting: "That which changes the mysteries of today into the commonplace facts of tomorrow is science in whatever guise". In 1952 we are entering a new phase of mystery and magic.