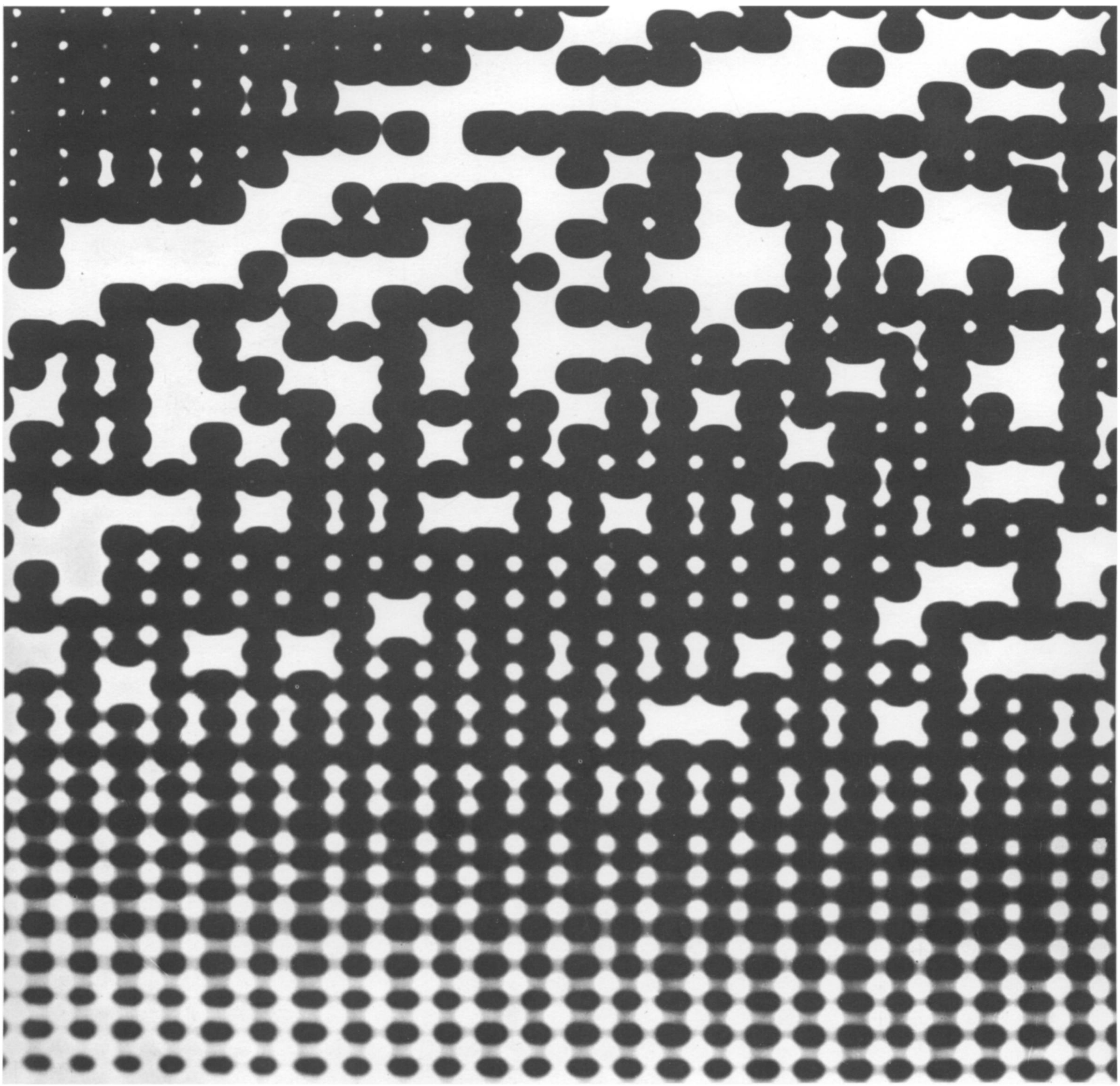
Design Quarterly 68

LIGHT AND DESIGN

by Gyorgy Kepes

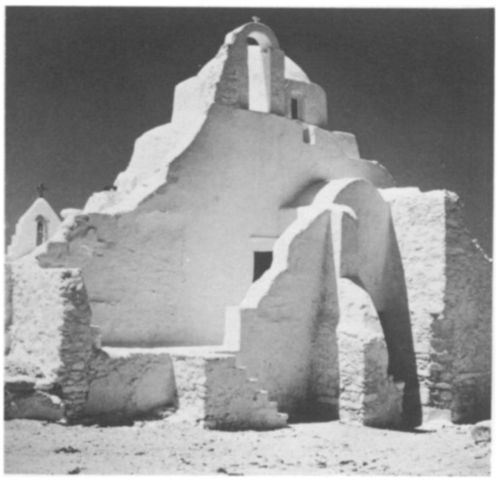
Walker Art Center Minneapolis Minnesota

Rhythmic light play



1 The Island of Paros, Greece.

2 The Towers of Automex, Mexico. Designed by Matias Goeritz; architect: Richardo Legometa.



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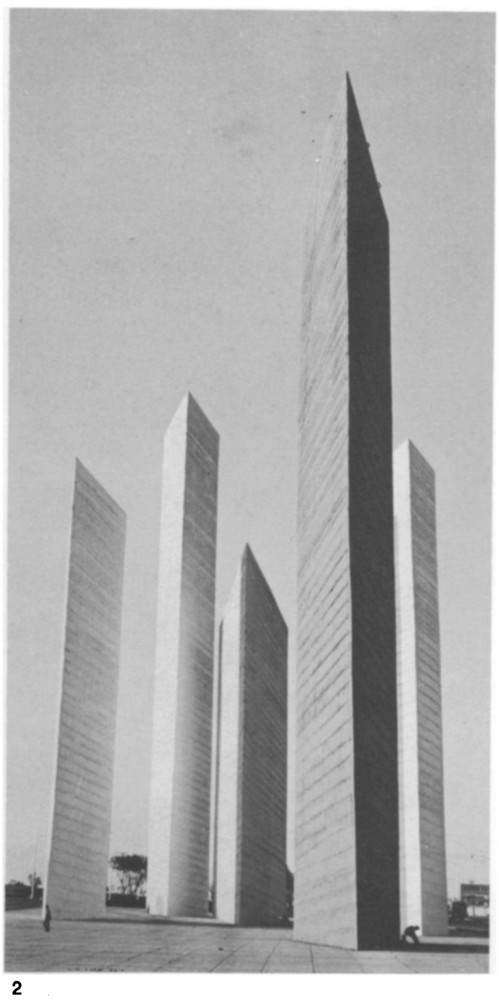

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LIGHT AS A CREATIVE MEDIUM

We know that there is a world outside us because our senses tell us so. The flow of sensations that impinges upon our bodies is crystallized by our nervous systems into sensed patterns. As we establish differences among those sensed patterns, we distinguish such separate units of our surrounding environment as earth, people, animals, trees, rocks, tables and chairs, and claps of thunder. As we discover similarities among them, we relate one unit to another, build larger unities, and recognize patterns and harmonies.

The senses of hearing, touch, and smell – important though they may be – are far more limited than vision and give fewer, vaguer, and less essential cues. Vision is basic and prior.

Everything that is seen enters the human eye as a pattern of light qualities. We discern forms in space as configurations of brightness and color. The whole visible world, natural and man-made, is a light world. Its heights and depths, its great outlines and intimate details are mapped by light.

When the artist or designer makes forms, he shapes light and the forms themselves become shapes of light.

Any manipulation of a physical substance is inevitably a modulation of light. Paintings and photographic prints are surface patternings of reflected light. Lantern slides and motion pictures are surface patternings of light that are first transmitted and then reflected. When a sculptor models clay, leaving imprints of his fingers, he is actually modeling with light. Each impression of his hand and tool on the pliant substance directs the traffic of light and shade. The traces of pigment left by the painter's brush are devices to catch a certain part of the light that falls upon the canvas. When a painter spreads different pigments on his canvas, he creates areas of different light reflections and absorptions. These, in turn, arouse through our eyes sensations we call colors. The physico-chemical microstructures of the pigments, through selective absorption, modulate the illuminating light into different wave lengths, which we sense as different color qualities.

Every architectural form, every building or group of buildings, regardless of the practical purpose or expressive need that formed it – stability, comfort, economy or symbolic meaning – is a visible form built from differences of light qualities, created by the different hues, textures, opacities, and transparencies of its materials. Without our perception of these patterns of light, our distance sense, our appreciation of the qualities of our wider space would completely disappear and our space would shrink to the reach of our fingertips.

There are four fundamental aspects of physical optics: the rectilinear propagation of light, the reflection of light, the refraction of light, and the diffraction of light. Of these, the first three are basic to ordinary human experience, and therefore to art and design.

Large or small, simple or complex, the unaided work of a craftsman or the cooperative product of a complex team of men and machines, every material object is ultimately a visible object to which light modulation is fundamental.

Carved wood, hammered silver, cast iron, ancient glass, newfangled plastics, poured concrete, oil-ground pigment, compacted snow, woven-and-cut velvet, cut-and-polished diamonds – each of these is a substance worked into a light modulator with a characteristic mode of distributing light. The structures of substances have a certain light-reflecting or light-absorbing capacity. Technical language calls it "reflectance" or "reflective index." There is a major difference in the amount of light returned from the surface of compacted snow and the surface of velvet fabric. Some of the substances are transparent; each of these is a medium through which a significant amount of the light that falls upon it will travel. Light rays change direction as

3 "Habitat 67," Expo 67, Montreal, Canada. This project departs from the conventional apartment building. Individual units are arranged on top of each other so that the lower units provide roof gardens for the ones above, producing an interesting play of light and shadows. Architect: Moshe Sadfie.

4 Three identical forms made from three different
5 reflecting materials: the first from a substance
6 producing diffused reflection, the second of polished metal producting regular reflection, and the third from transparent plastic. All photographed under identical light conditions.

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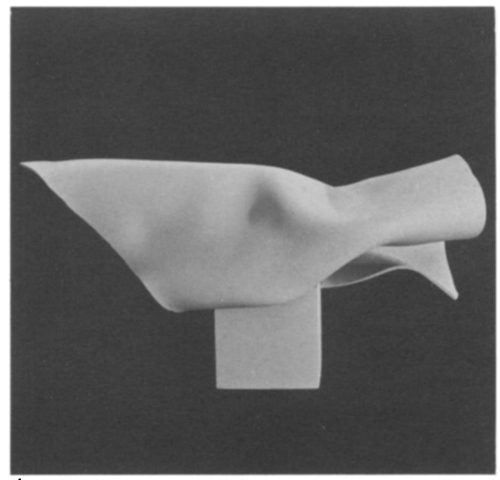

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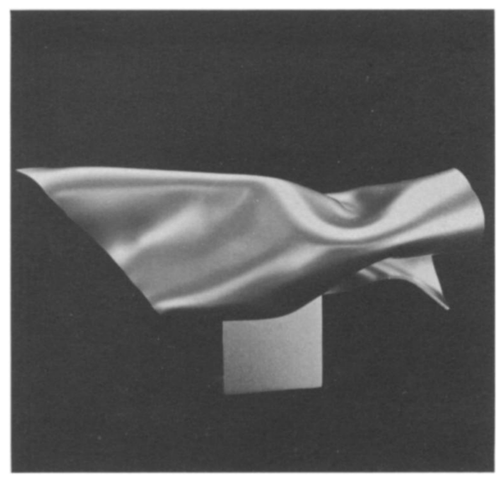

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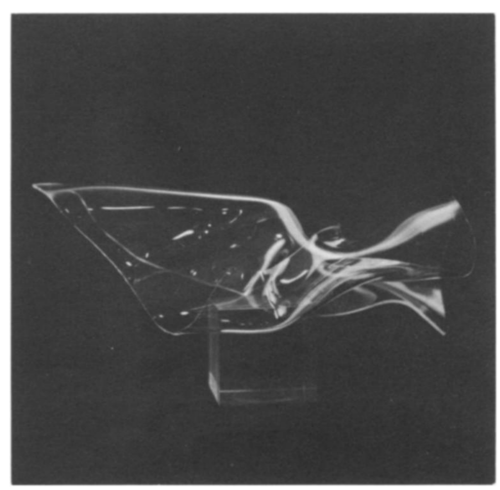

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7 "White form" by Norman Carlberg, 1962. Epoxy over plaster core.

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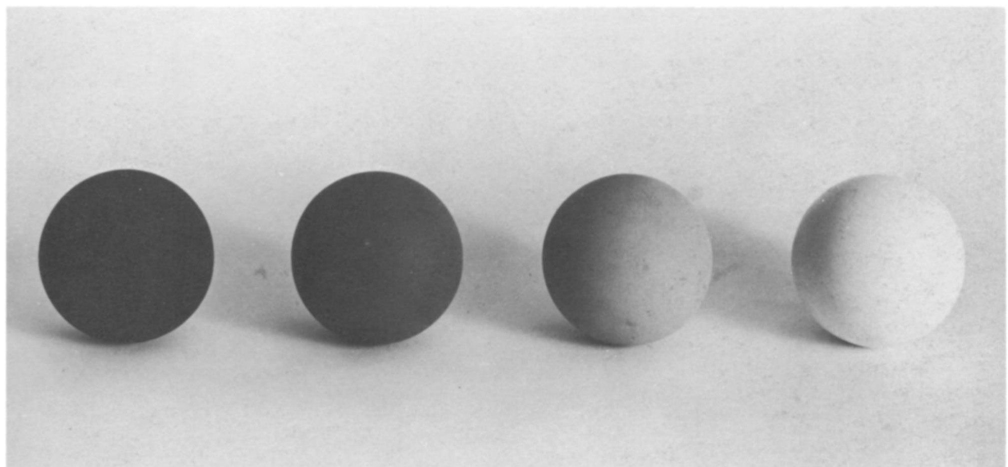
8 Under identical illumination the legibility of an opaque three-dimensional form will depend upon its index of reflectance. If, for instance, four identical forms are painted with pigments of different reflectance—one white, one light gray, one dark gray, and one black and illuminated the same way—the form painted white, having the highest reflectance, will be the most legible; the black, having the lowest reflectance, the least. Study from M.I.T. Visual Design Course.

9 "Cubi IX" by David Smith, 1961 (detail) Collection: Walker Art Center

they pass from a medium of one density into a medium of another density, for they follow a path that will take them through the medium in the minimum of time. The light is said to be "refracted;" and each such substance has a "refractive index." Plexiglass, window glass, and diamond crystals bend light at different angles. (Each, in addition, has a different "dispersive index," for each has the power, although not to the same extent, of breaking up white light into the various color frequencies of which white light is composed.) Let us examine three substances markedly different in structure and the ways they modulate ordinary light which travels in a straight line.

The first of these substances is snow which is made up of tiny transparent crystals. The facets of these crystals are highly reflective, so that, in the mass, snow returns all the light rays that strike it, and it becomes uniformly white. Worked into a sphere and exposed to clear sunlight, it gives us a simple, strong, easily readable form. The sun's rays strike that portion of the snowball's surface which faces them; they travel on past that portion of its surface which is turned away. The snowball is blinding white where illuminated; the rest is in shadow and we read it as a spatial volume, as a solid form, not as a flat disk. This dialogue between the substance and the source of light is the key to the snowball's manifest convexity.

Simple modeling by light and shape of a substance substantially uniform in light reflectance has been the central expressive resource of sculptors, from the men who created statues of gods and Pharaohs in ancient Egypt to Aristide Maillol, Naum Gabo and David Smith. After five thousand years, it is still our most effective means for the unequivocal statement of solid forms. The lesson has not been lost on painters: Giambattista Tiepolo, for example, the great eighteenth-century Venetian, employed such simple means in pen-and-wash drawings of the most dazzling sophistication and virtuoso skill.



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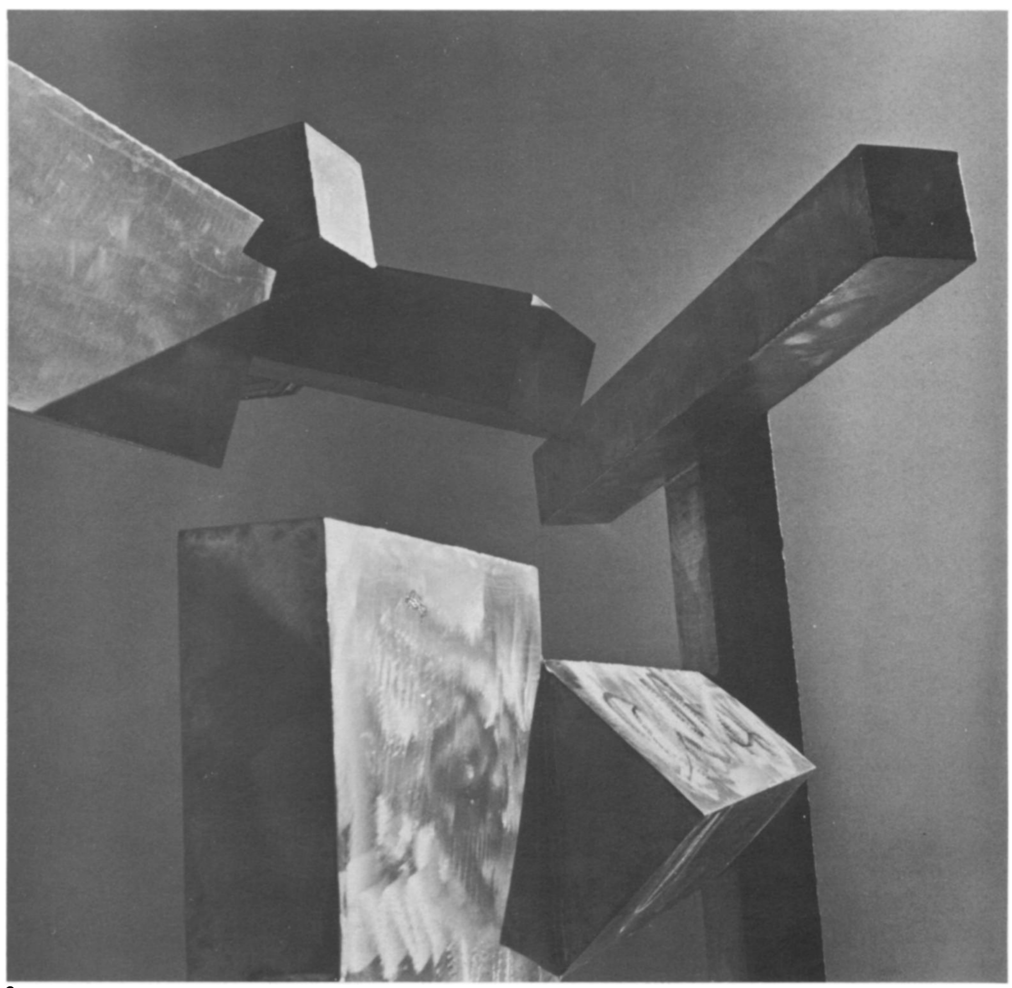

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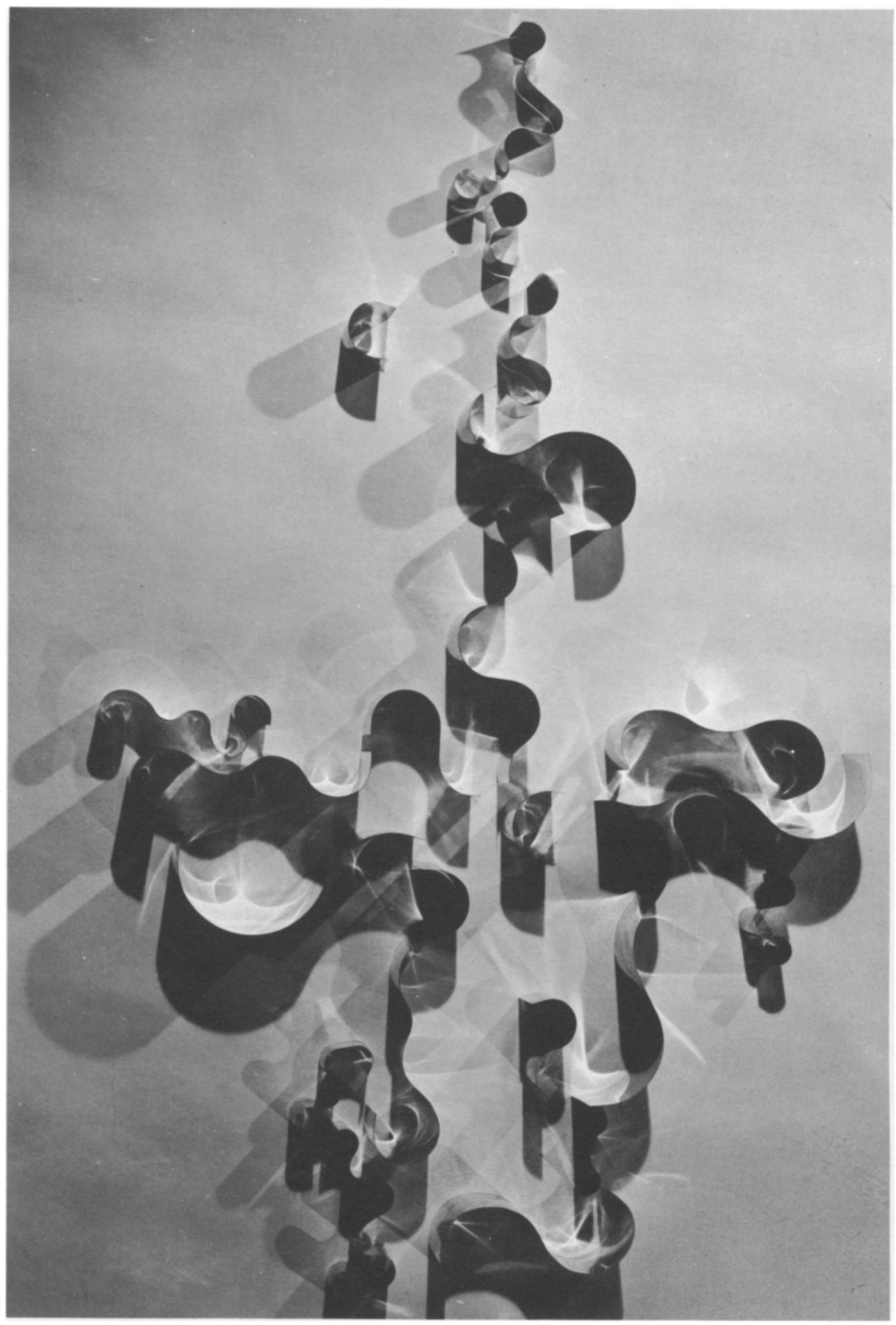
10 Mural project. Complex light reflections produced by highly-polished metal surfaces of different curvatures. Study from M.I.T. Visual Design Course.

The second substance is velvet, a textile loomed of silk or wool, with a soft, plushy nap. In cross section, it consists of tufted rows of threads rising from a firm foundation. When light from some source of illumination falls on the velvet, most of the light rays sift through the gaps between threads and are absorbed. Some light rays collide with the standing threads; after many reflections they return to the surface in spent array. The returned rays have the rich, saturated hue of the velvet itself. The extremely few rays that strike the very tips of the pile are not absorbed; they are reflected back to the eye. These rays have the same color as the source of illumination — white if the source gives off white light — and give velvet its familiar glow. Cut velvet is then a light-trapping substance. Its inner formation modulates light in a variety of ways for this substance is not uniform but varied in light reflectance. The reason for velvet's characteristic texture is its lattice of deep, rich color and soft sheen.

Titian, Rembrandt and Van Gogh are painters who not only depict deep, rich, glowing fabrics but create deep, rich, glowing textures physically, with paint. They did this by creating light-trapping substances, structurally similar to the inner formation of velvet. Over a dark, coarsely grained canvas, Titian laid an underpainting in broad, heavy strokes of red and gray, but did not cover the canvas completely. Over the underpainting and the canvas background he placed several transparent layers of glazes and scumbles, light over dark, dark over light. Here and there — in depicting a ruffle, perhaps, or a glimpse of shirt — he placed accents of white, loading the paint rather heavily. Light that falls upon the painting from an illuminating source passes through the layers of glaze, and after having been reflected forward and back from layer to layer, returns, spent, to the surface and to the eye. The few returned rays give the paint the rich, saturated hue of the velvet itself. The whole painting thus becomes a



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11 Hilton Tel-Aviv Hotel. Architects: Y. Rechter, M. Zarhy.

12 Highland Park Senior High School, St. Paul, Minn. Architects: Hammel, Green & Abrahamson, Inc.

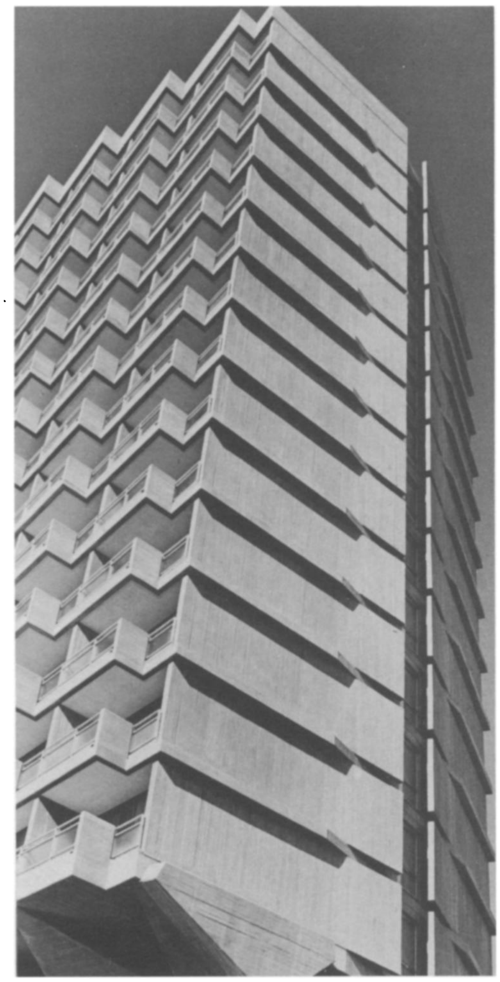
marvelous substance, not uniform but varied in light reflectance which gives such works its characteristic texture, its rich color and soft glow. Rembrandt created a visually similar texture by more direct and freer means. He built the surface of a painting in depth, with grooves and striations and modeled strokes, while Van Gogh laid paint on a canvas thickly, developing a corrugated surface of hills and valleys so most of the oncoming light is absorbed in the hollow depths, sending back saturated color rays but no directly reflected white light. The prominent ridges are the only parts of the surface to reflect white light. The overall effect is of velvety, saturated depth, and the physical structure of his surfaces is an analogue of velvet.

The third substance is a diamond crystal, faceted by the lapidary into a characteristic micro-architectural form. The diamond exceeds all other substances in its power to refract light and almost all others in its power to disperse light. Because of the diamond's refractive power, most of the light rays that fall upon the brilliant do not pass through but are reflected back inside by the clean, smooth planes that bound its mass; they travel round and round inside before escaping to the eye. Because of the diamond's dispersion power, the light rays splinter into all the colors of the rainbow. The fiery, brilliant, flashing concentration of light is poles apart from the light modulation accomplished by cut velvet.

The structures of such substances as snowballs, velvet, and diamond brilliants are paralleled on a larger scale in man-made environments. Men have instinctively recognized and made appropriate use of the light-modulating properties of their building materials, and each such material has a certain light reflectance in accordance with its intrinsic molecular grain. There is a major difference in the amount of light returned from a whitewashed wall and from a deep-stained timber. Each reflectance offers qualities to the eye and rules of the game by which the things made from those substances are read as spatial forms.

Many lands where the sun is bright and the sky deep blue have a simple, strong, convincing architecture that takes full advantage of light reflectance. The indigenous white buildings of the Greek islands, for example, play with sunlight. They stand against an unobstructed sky, from which the dazzling light of the sun pours down. The simple, white forms with their strong masses and lucid geometry, cut into this space-filling, luminous substance; and a crisp, strong counterlight—a shadow—reveals each interception of the oncoming light.

This simple and modest architecture owes its gem-like brilliance to the strong light that falls upon it, yet it owes its legibility not to light alone but to counterlight as well. Because the white surfaces are completely uniform in light reflectance, their spatial multiformity is made clear to us by the variations in the amount of light they receive. Those variations depend upon how the buildings and the forms of which they are composed are oriented with respect to the light source. Surfaces set at right angles to the oncoming light rays receive a maximum amount of light. Surfaces set at an angle greater or less than a right angle receive less than the maximum. And those surfaces set at an angle less than the angle of the light rays themselves receive no light at all because the light rays have been intercepted; they are in shadow. Curved surfaces vary continuously in the amount of light they receive as far as the line at which, if their curvature is strong enough, they receive no direct light at all. Shading thus models the forms, and we read meanings in the shapes and values of shadowed areas: what is straight, what is angular, what is convex, what is concave. Cast shadows, which occur when one form interrupts the light that falls upon another, tell us—through their length, their shape, their sharpness of edge—about the spatial extension of forms: where they are located, what are their dimensions. Cast shadows encode space.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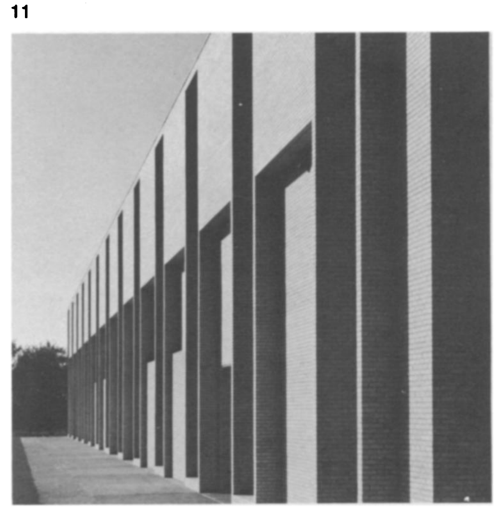
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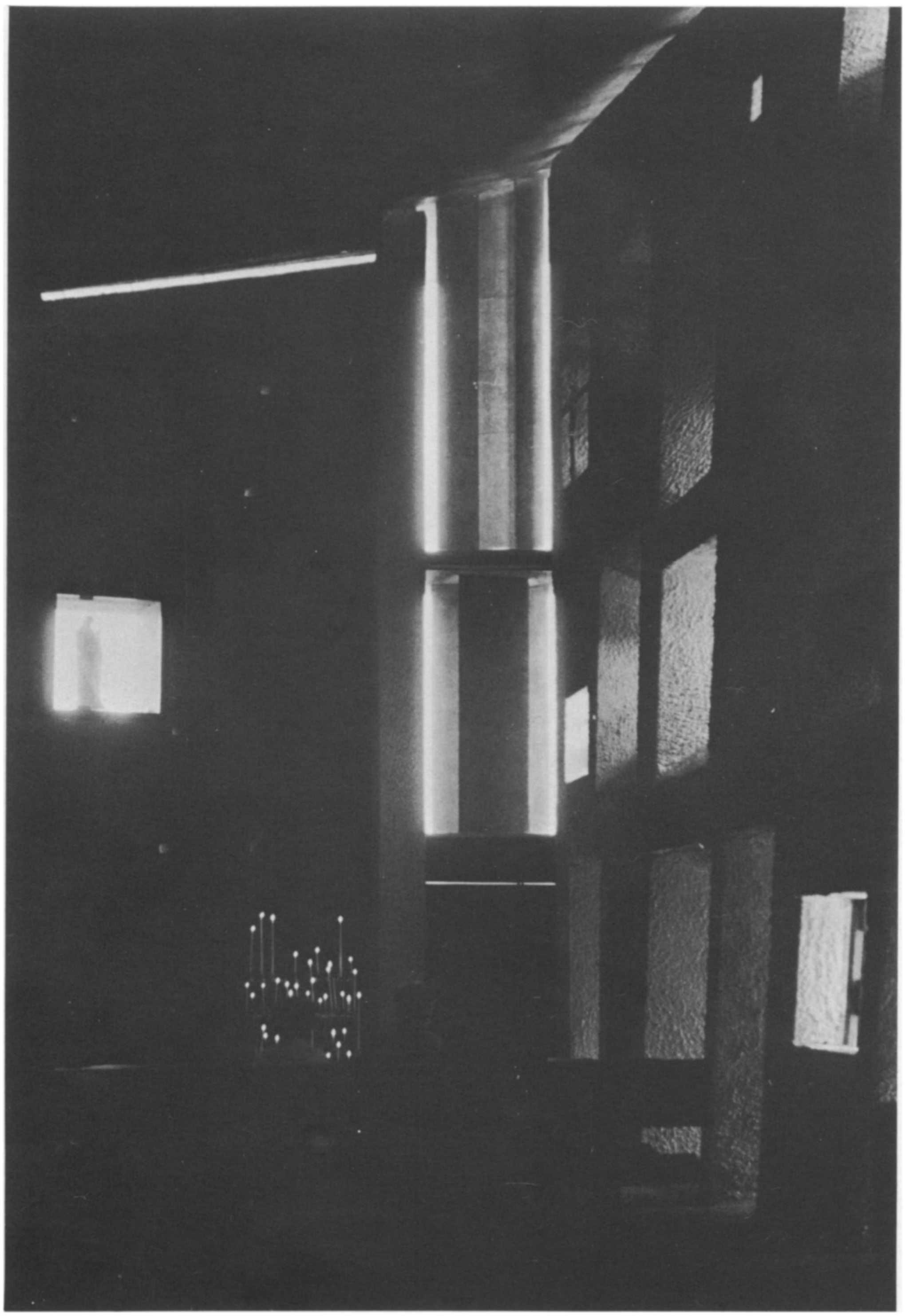
13 Interior of Ronchamp Chapel, Le Corbusier, Architect. The sunlight entering through the windows is mellowed by various light-modulating devices: first by the deep funnel-shaped window apertures and second by the sculptured opaque buffers that disperse the entering light into soft interreflections.



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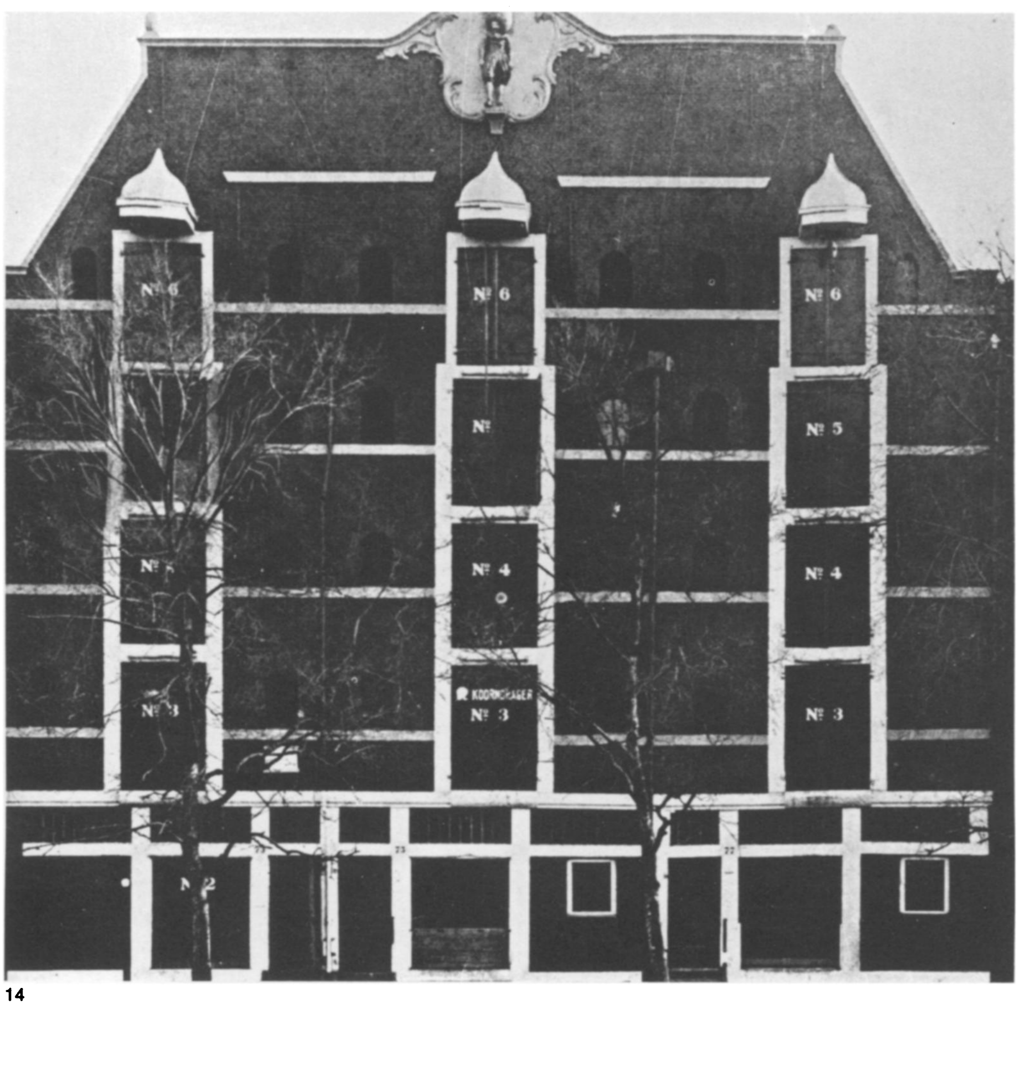
All too unconsciously, we decode the messages, and build a simple but very precise vocabulary and grammar of the immense variety of spatial character of the architectural forms.

Architects on the most sophisticated level come back again and again to such simple devices of light modulation. Le Corbusier's chapel at Ronchamps is an impressive contemporary example of clarity and strength of form achieved by limiting the space-enclosing surface to one level of light reflectance.

The spatial world is made legible not only by the distribution of light and shadow, but also by the distribution of pigments. Besides the dark accents which are produced by the nearby total absorption of the light incident to the surface, and white, produced by the nearly total reflection of the incident light, there are visible qualities of the environment we call "colors" which are produced by the unabsorbed light reflected by objects. The visible world is, then, woven for us from these two separate effects, similar in appearance but fundamentally different in physical origin.

If we look around us, we discern spatial areas as combinations of the two modes of light modulation. Sometimes one mode dominates, sometimes the other. When we look at a human face, we see total differences among its dark hair, pale skin, blue eyes and red lips. These differences are inherent in the pigments, and are produced on a miniature scale of light modulation. The forms of the head, the sculptural shapes of the cranium, of nose, and chin are given to us by the interplay between the surfaces and the incident light.

For various reasons, artists and designers have emphasized one mode or the other in their expressive work. There are great architectural forms that do not exploit light and shadow, but draw or paint space by means of a lucid structuring of the various materials used to enclose it. Rather than one uniform light-reflecting material, two or more materials are chosen, contrasting in light reflectance. The Katsura Palace in Japan is built, physically and visually, of frankly opposing materials. The key units are the deep, dark wooden timbers and the brilliant, white walls. The Katsura Palace exhibits a crisp, clean contrast of near black and white and a crisp, clean contrast of horizontals and verticals. The dominantly rectangular relation of beam to column is repeated as an optical echo in the dominantly angular relation between white and black. In a manner that resembles the gradual merging of form into form in some Greek island buildings, the angular sense of the black-and-white contrasting forms becomes an intermediate step between the horizontal and the vertical sense of the horizontal-vertical-contrasting forms. The space is read as a sequence of white figures with each area clearly defined by its black boundary lines. A creative decision was made to choose a certain set of information that, at the same time, would reveal a tectonic of space and provide a rhythm of areas, directions and sizes; the observer does not take in the work with one steady gaze, but explores the space in the way that a person moving through woods explores the rhythmic interplay between tree trunks and leaves. There is hardly any gradation of tone values.



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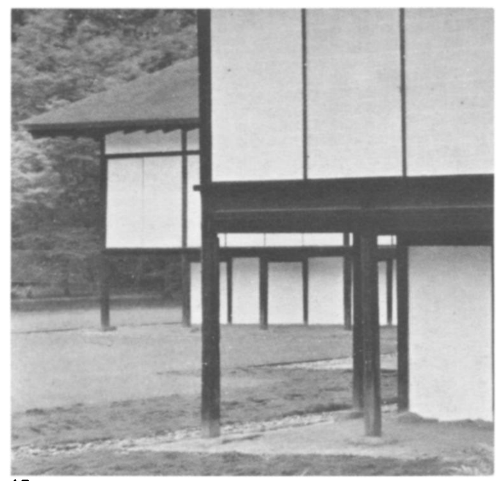
14 Warehouse in Amsterdam. Different reflectances are used to articulate the facade.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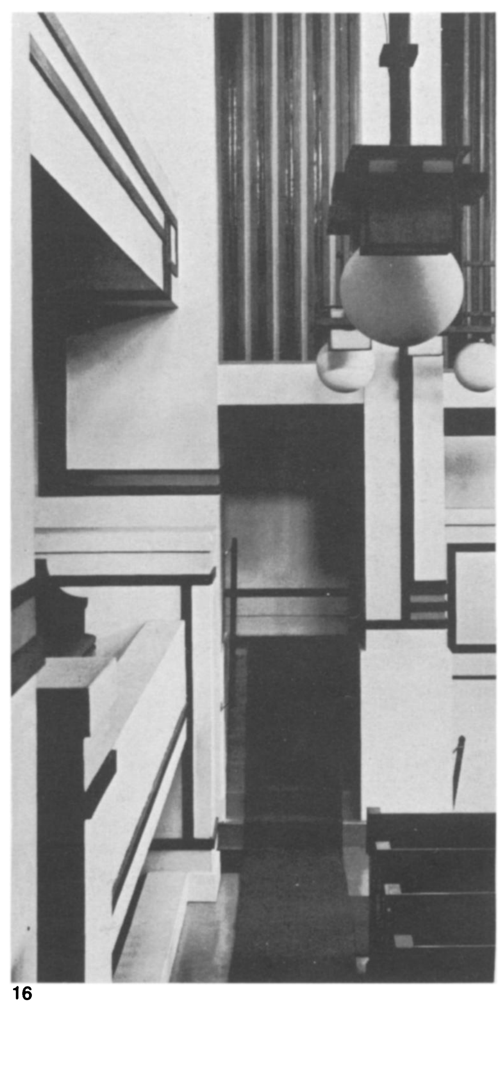
15 Katsura Palace, Kyoto, Japan. The Middle Shoin and New Palace seen from the south side of the Old Shoin.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16 Entrance detail of the Universalist Church, Oak Park, Ill., 1900. Architect: Frank Lloyd Wright.

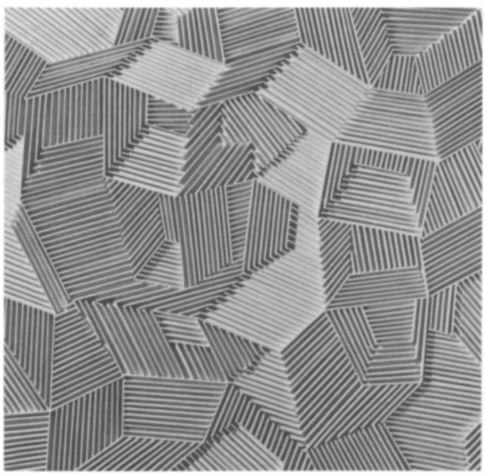
17 Three texture studies: the relative brightness value
18 of an illuminated textured surface depends upon
19 the angular relationship of the dominant direction of the textured grains to the direction of the illuminating light. A low sidelight touching a striated textured surface at right angles to its dominant texture direction will cast deep shadows. A low sidelight coming parallel with the striations will cast no shadows. Studies from M.I.T. Visual Design Course.

20 Mayan architecture, Yucatan, Mexico, circa 800 A.D.: detail of a frieze on the Palace of the Governor.

21 Acoustic ceiling made up of two modular units of prefabricated acoustic tiles. Each unit has a different subdivision of a square which is created by the changes in the direction of the striation of the surface. Designer: Gyorgy Kepes with Robert Preusser.

22 Detail of a light reflecting mural. Designer: Gyorgy Kepes.

23 Optical texture created by multiple shadows on a
24 surface articulated by varying dowels and light.
25 Three studies from M.I.T. Visual Design Course.



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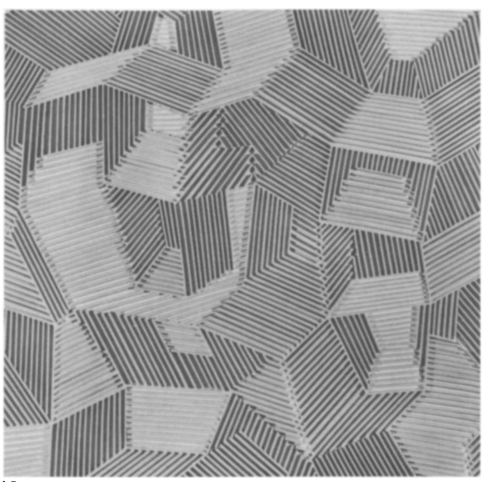

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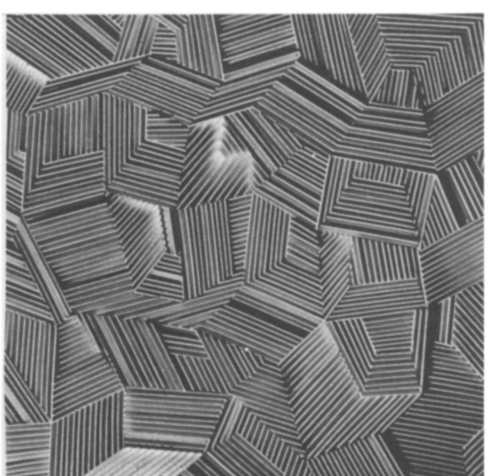

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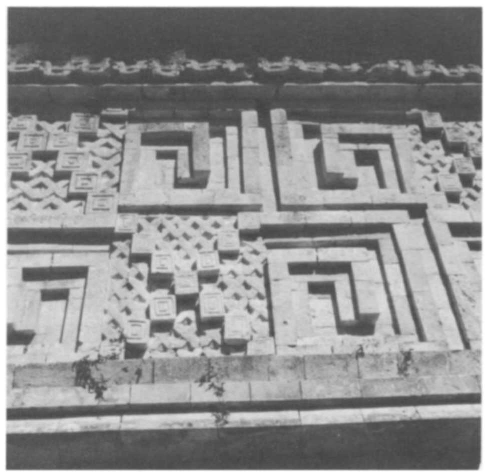

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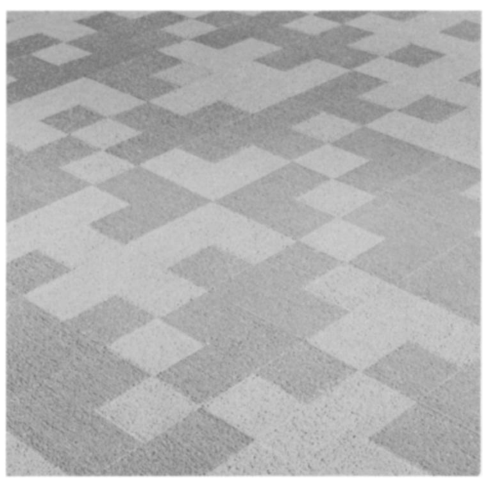

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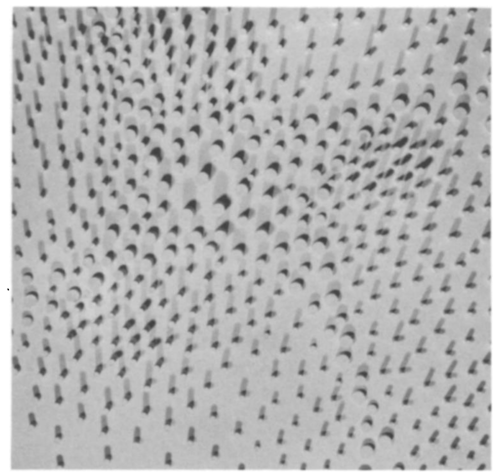

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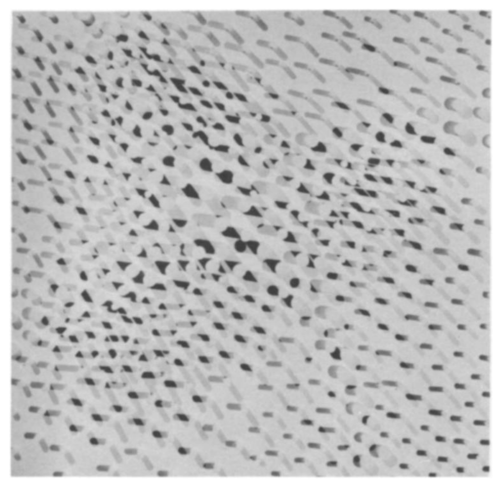

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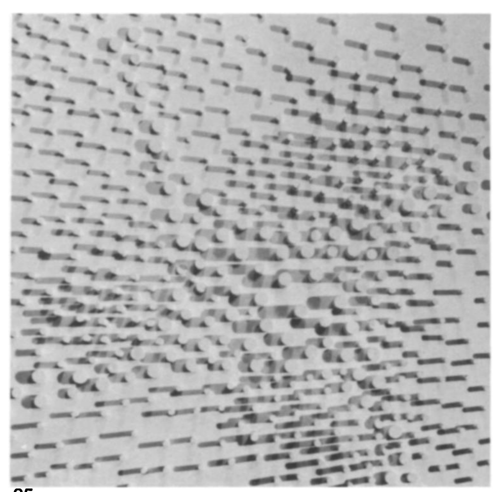

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28 Micrograph of a platinum crystal magnified 500,000 times. Prof. Erwin Müller, Pennsylvania State University.

29 Two views of an aluminum surface subdivided
30 into areas with different directional grains. By changing the light conditions, the directional grain emphasizes different forms of the surface. Designer: Karl Gerstner.

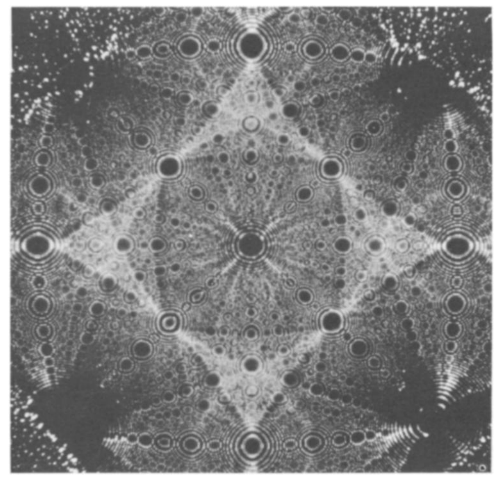
Our eyes often receive documentary information about forms in space from light that does not come directly from the forms themselves. Photographs, motion pictures and television images are light patterns gathered by a lens and recorded on a photo sensitive emulsion of a fluorescent screen. Every such image is a term in a series of light modulations before and after it reaches the human eye.

The lens of the photographic camera collects light patterns from the environment in a focused image. The photosensitive emulsions on the film register this focused image, first as an invisible latent image, then, after chemical processing, as a visible negative pattern. Then the negative is converted into a positive print—an analogue of the original brightness pattern caught by the camera. Finally, the lens of the eye, the photochemistry of the retina, and electric signals traveling through nerve conductors to the brain form the imaged space.

The images formed with the assistance of television are the rear guard of an even longer parade of pattern that begins with an event in space, transformed into electronic signals along a complex route, and ends with an event in our brain.

The brain retains its impression of a light signal, that has entered the eye, for a tenth of a second after the signal disappears. Consequently, if the impressions our eyes receive follow one another at appropriate intervals of time, we perceive a series of such impressions continuously as moving pictures. The television camera scans each pattern of light and shade, dissecting it into some 200,000 separate units. The pattern is then reassembled before our eyes, one unit at a time, as a grid of light signals flashing on and off; the events we see are both simultaneous and successive. Thirty pictures are presented in a second, each made up of 200,000 light units recorded one after another—6,000,000 units every second. Those thronging impacts are processed by the extremely complex human eye. The retina of the eye has some 400 million cone receptors and is connected to the brain by the optic nerve, a rope of a million fibers. The light signals, now transformed into electrical signals by the optic nerve, are woven by the brain into form, meanings and a sense of spatial depth, and into responses to such visual qualities as proportion, rhythm, and melody of line and tone.

26 "E. Motion Picture No. 2." Sequence produced by
27 three rotating light-reflecting patterns. Designer: Karl Gerstner.



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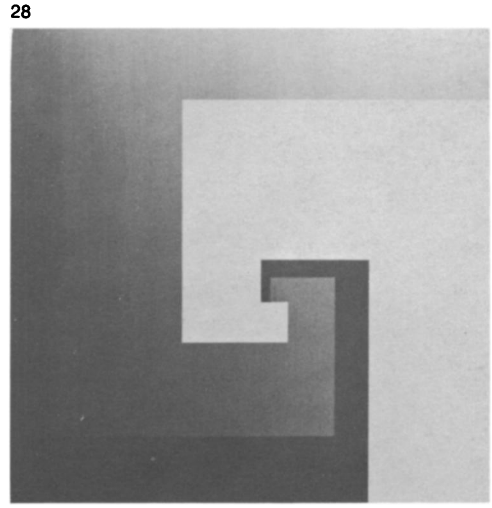

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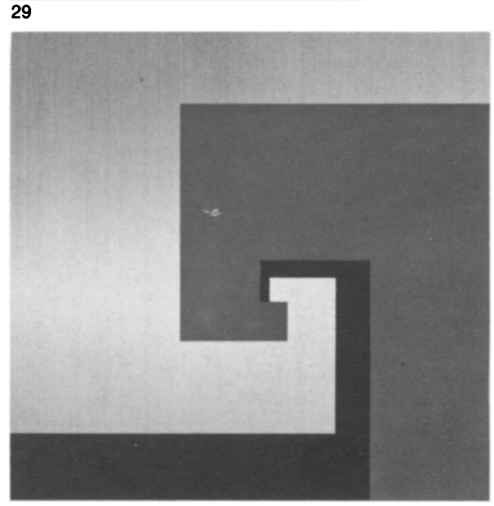

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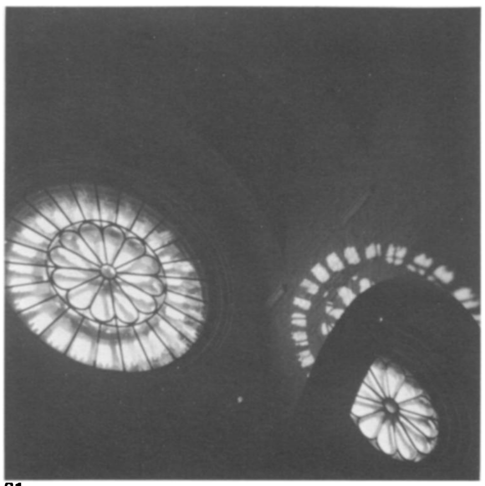
31 *Projected* window lights at the St. Francesco Cathedral, Assisi, Italy.

32 "Continuel Lumiere," kinetic light design by Julio Le Parc, 1962.

33 Peruvian fabric, Paracas Peninsula, circa 800 A.D.



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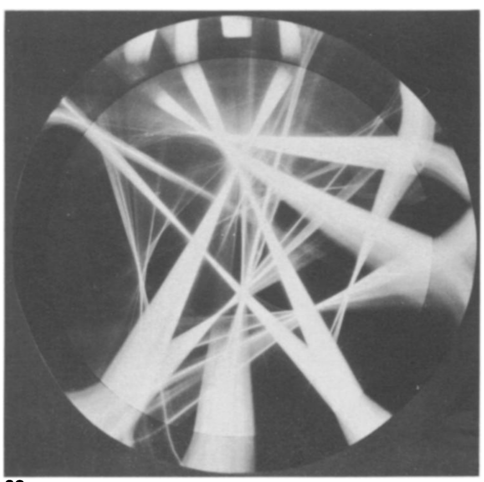

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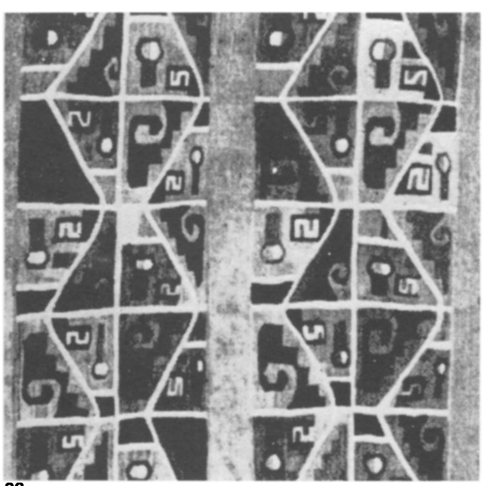

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LIGHT AND COLOR

Today, we understand the interaction of colors. One aspect of what we see we call "subtractive color mixing." That is, pigments of two different colors, when mixed together, create a third color. Each pigment absorbs part of the light spectrum emitted by the other and amplifies that part of the spectrum which the two have in common. The common part of the spectrum emerges as the new color. This phenomenon occurs on the molecular level of pigments, a level so different from our own gross scale of orientation that it is difficult to explain except through analogy. Sir William Bragg compares the individual pigments to tuning forks tuned to different frequencies.[1] Just as a tuning fork will vibrate if struck by the sound vibrations from another the same in frequency, so the atoms and molecules of pigments vibrate, emitting light waves of the frequencies to which they are used—one red, another blue, and so on.

In the fifth-century mausoleum of Galla Placidia in Ravenna, Byzantine masters of mosaic created a rare crescendo of light. Under a blue vault, a few gold stars sparkle with impressive fervor; individual glass tesserae inserted in the plaster at random angles to the plane of the wall produce a shifting, never-ending pulsation of irregularly reflected light. As our eyes move, the angled tesserae reflect light at different moments, creating one light-and-color impact after another. The prevailing color of the mosaics is a rich blue against which we see the magnificent hieratic figures. Sunlight filters in through thinly-sliced alabaster window panes, bathing the mosaics in a soft yellow glow. The tesserae set to catch the light are tinted yellow. Those set against the light are shaded the complementary tone of the incident light and attain the bluest of blues. As the spectator moves, the shimmering waves of blues and yellow fuse in his eye like the dots of color of a pointillist painting.

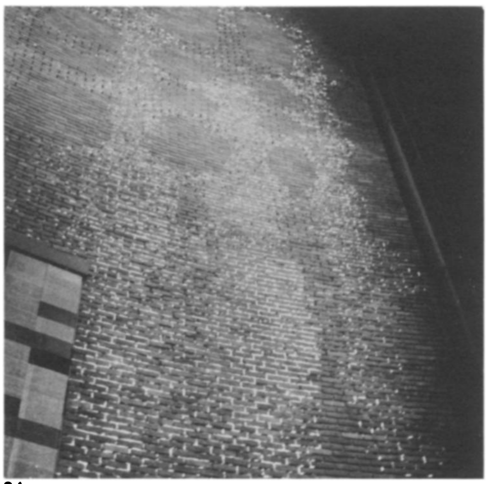
The luminous brilliance of the blue background of the Galla Placidia mosaics is greater than the inherent brilliance of the blue tesserae. Although this optical triumph was achieved in the fifth century, the reasons for that brilliance were not understood until the nineteenth century. In his *Commentatio,* 1823, the Czech physiologist Purkinje set forth precise observations about the behavior of colors viewed in weak light. In twilight, the relative brightness of color values change; red and orange objects appear to lose their color, becoming black or gray; blue or green objects appear to increase in brilliance. The subdued light of the interior of the mausoleum of Galla Placidia is the condition that amplifies the brilliance of blue.

In fifth-century Peru, long before the Incas, the weavers on the Paracas peninsula were so skilled and sophisticated that we cannot duplicate today the techniques and qualities of their embroidered fabrics which were equal to the great mosaics of Ravenna in richness and vitality. The dyer's palette that they used comprised a wealth of intense colors. Altogether, they had a fund of nearly 200 colors, and used as many as 25 in a single embroidered panel. The range of textural qualities was comparably wide. The fabrics are organized in depth; their surfaces, varying in height according to the density of the weave, are made up of continuous and dotted lines arrayed in rows of ridges and grooves, of lowlands and plateaus. Their regularities and irregularities are like those of ploughed farmland seen from the air. When luminous rays strike the surfaces, an all-but-visible film of light intensifies the strong, pulsating colors. The light generates counterlight that accents the textural structure. A most intricate play of light and counterlight takes place on many levels of perceptual organization—individual pattern units; hollows and prominences; lines, rows, and areas; the complex surface as a whole. Light, color, and texture interpenetrate, separate, and coalesce to form harmonies and oppositions of directions, line, shape and tone.

34 Sixty-five foot high brick wall embellished with Venetian glass mosaics placed in the mortar between bricks. Pink Mexican bricks combined with turquoise and emerald glass mosaics offer a rich optical play. Temple Emmanuel, Dallas, Texas, 1958. Architects: Wurster, Myer & Sandfield. Designer: Gyorgy Kepes.

35 "L—9," motorized plexiglass by Herbert Gesner.

36 Detail of "Entrance to the Harbor, Port-en-Bessen," oil on canvas, by George-Pierre Seurat, 1888.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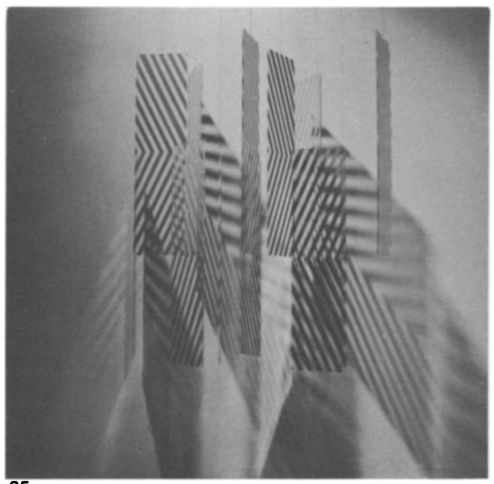
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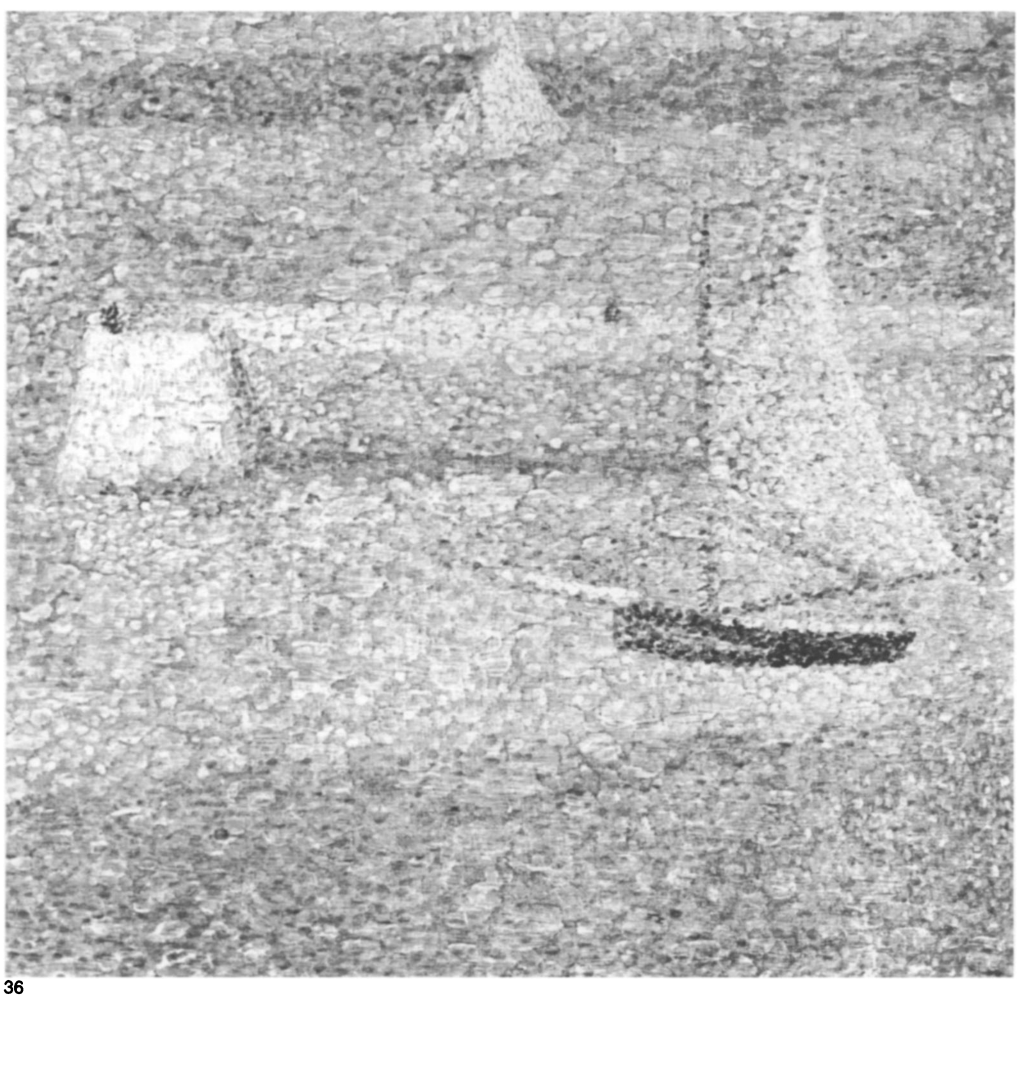
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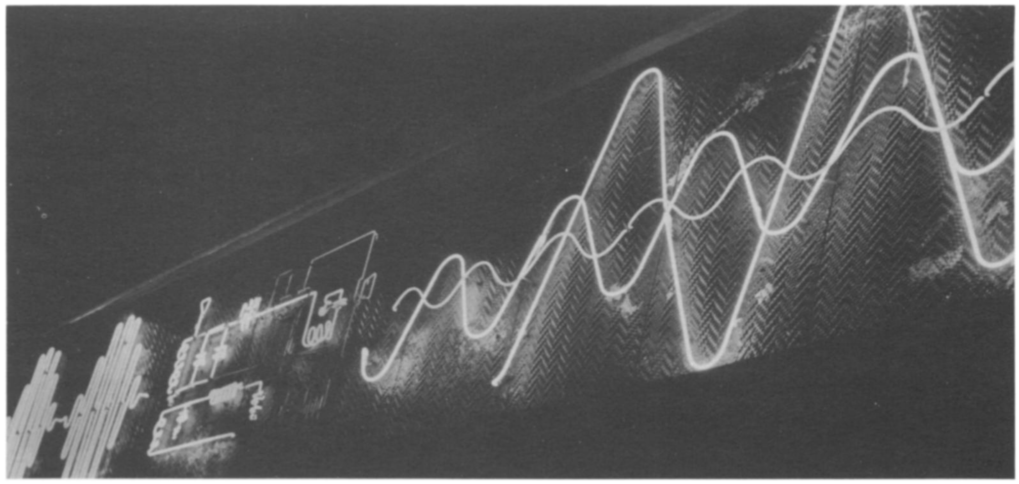
The ordering of color in those early fabrics embodied principles that were consciously formulated no earlier than the beginning of the nineteenth century. The first comprehensive study of the interaction of colors was undertaken to cope with problems that the Paracas weavers had encountered and solved fifteen hundred years before. Chevreul,[2] the great French chemist, was approached by a Gobelin factory to determine why certain colors in Gobelin tapestries faded or changed. Were some of the dye pigments impermanent? Chevreul investigated the phenomenon and concluded that the causes were not chemical but perceptual. He noted that, if one looks at two juxtaposed stripes alike in hue but different in brightness and chroma, or alike in brightness and chroma but different in hue, a tension between the two tones is generated in the observing eye. The perception of color intensity—of other optical properties, too—is different from the identical tones in isolation. Opposite colors placed side by side seem purer. Because of the specific laws of what Chevreul called "simultaneous and successive contrast," color is now looked upon as governed by the general laws of field phenomena, wherein change in any part of a field brings changes in the rest of the field.

Count Rumford, another investigator of color phenomenon, put forward the idea that two colors, if they are to harmonize with each other, must present colored light in the respective proportions necessary to form white light.[3] Thomas Young described and interpreted these phenomena with convincing precision: "When the eye has been fixed on a small object of bright color, and is then turned away to a white surface, a faint spot, resembling in form and magnitude the object first viewed, appears on the surface, of a color opposite to the first, that is, of such a color as would be produced by withdrawing it from white light; thus a red object produces a bluish green spot; and bluish green objects a red spot. The reason of

37 Outdoor mural composed of tubular lights of various colors. Designer: Gyorgy Kepes, 1951.

38 Projected light reflections. A scene from a light ballet recorded on photosensitive emulsions. Designed by Otto Piene, 1960.

this appearance is probably that the portion of the retina, or of the sensorium, that is affected, has lost a part of its sensibility to the light of that color, with which it has been impressed, and is more strongly affected by the other constituent parts of the white light. A similar effect is also often produced, when a white, or gray object is viewed on a colored ground, even without altering the position of the eye: the whole retina being affected by sympathy nearly in the same manner as a part of it was affected in the former case. These appearances are most conveniently exhibited by means of the shadows of objects placed in colored light: the shadow appearing of a color opposite to that of the stronger light, even when it is in reality illuminated by a fainter light of the same color. It seems that the eye cannot perfectly distinguish the intensity of a color, either when the light is extremely faint, as that of many of the fixed stars, or when the light is excessively vivid; and that when a considerable part of the field of vision is occupied by colored light, it appears to the eye either white, or less colored than it is in reality: so that when a room is illuminated either by the yellow light of a candle, or by the red light of a fire, a sheet of writing paper still appears to retain its whiteness; and if from the light of the candle we take away some of the abundant yellow light, and leave or substitute a portion actually white, the effect is nearly the same as if we took away the yellow light from white, and substituted the indigo which would be left: and we observe accordingly, that in comparison with the light of a candle, the common daylight appears of a purplish hue."[4]



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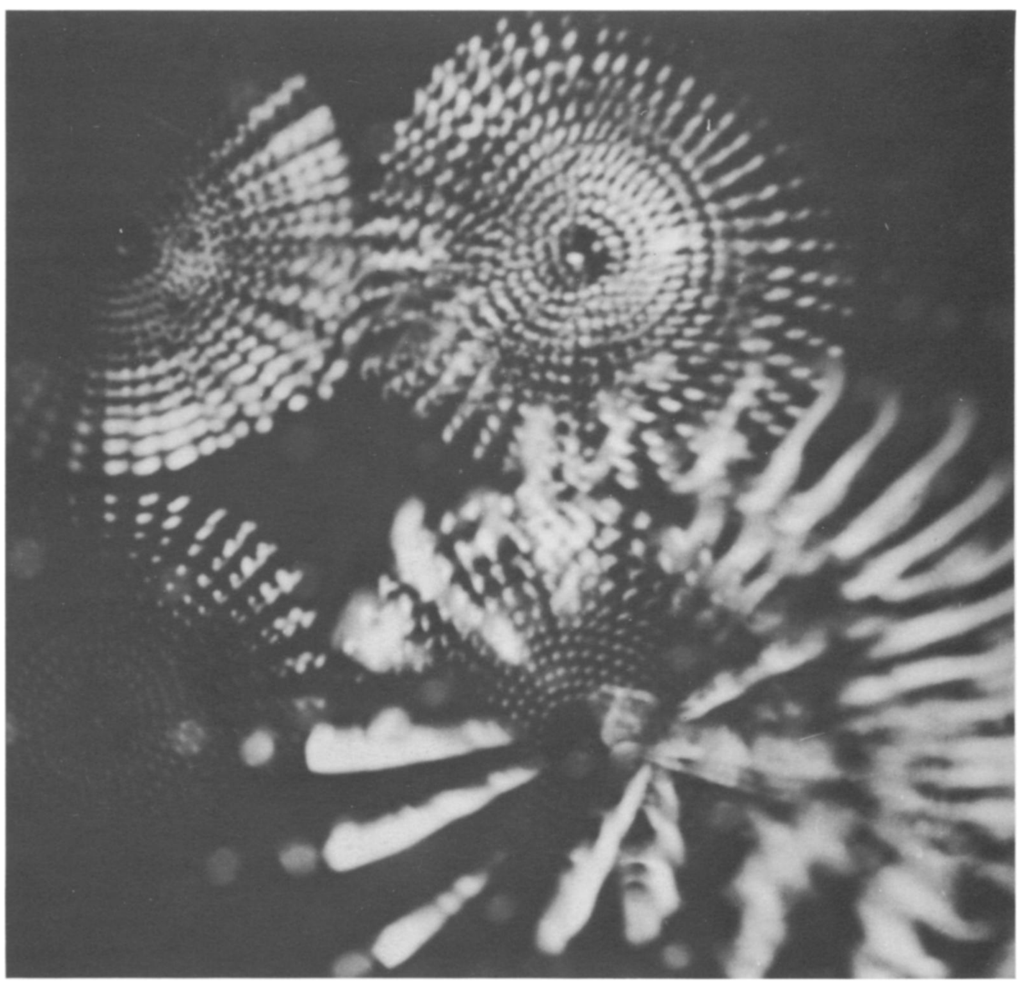

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Color harmony is developed when, among juxtaposed tones, one of the three major dimensions of color—hue, chrome, brightness—is held constant, or almost constant, and the other two dimensions are made to vary. A higher degree of harmony, of course, is developed when two are constant and the third varies. Such harmonies

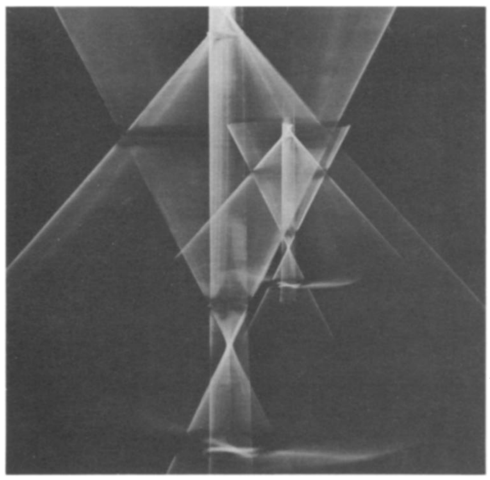
39 Light projection on photosensitive emulsion. Study from M.I.T. Visual Design Course.

40 Optical distortion of geometrical patterns reflected in an irregularly-curved, highly-polished material.

41 Canopies of trellises, mats, nets or vines are used to distill the raw sunlight into a sort of optical liqueur in this example of a semi-covered arcade in Nigeria, Africa.

may be produced in either of two ways. The first is by subjecting juxtaposed tones to strongly colored light (which lends them similarity of brightness). That method was systematically employed in the mausoleum of Galla Placidia. The second is by selecting tones for juxtaposition such that in themselves they fulfill the conditions for color harmony. This method was employed in the Peruvian fabrics, presumably more by instinct than by application of clearly defined scientific principles.

Advances in the scientific understanding of color enabled painters of the later nineteenth century not only to expand optical knowledge used instinctively by the masters of the past but also to develop a new level of awareness of the potential color in artistic expression. With Seurat and Cezanne, understanding reached great sharpness of focus and height of discipline. What the Ravenna masters of mosaic achieved with their perceptive instinct and accumulated craft, knowledge was now focused into a crystalline structure of conscious theory and carried out with great intelligence, system, and command—a combination of the scientist's conceptual mode of thought and the artist's visual sensibility. Those painters felt that the painted image could no longer be a mere mirror of the brightness structure "out there" in space. Rather than a set of represented lights and shadows made with paint, they placed upon the canvas a light-and-color structure formed in accordance with the responses of the human eye. They were trying to construct a surface that, in a very convincing way, could exist in its own right quite independently of any reference to the brightness structure of spatial objects. In making something that was itself "alive," they were also making something that provided the human eye with a living experience. For surfaces that never change in color for us convey no optical pulse beat, no radiance; they may have power, but not life. "Living" surfaces change in optical character. Satin and rippled water shimmer, flicker, and alter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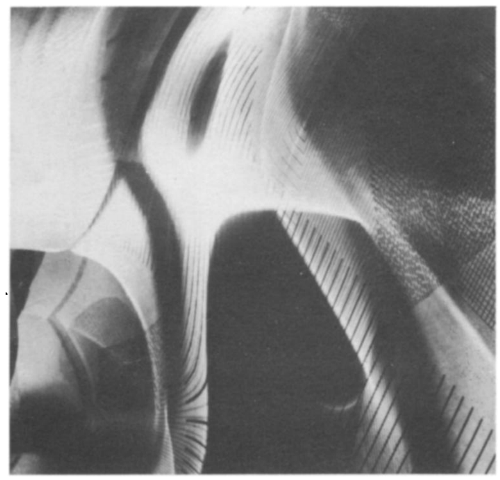
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42 Light patterns projected on photosensitive emulsion.

43 Strain diagrams, photo-elasticity records by Prof. William M. Murray, Massachusetts Institute of Technology.

44 Mural composition of a sequence. Light study from M.I.T. Visual Design Course.

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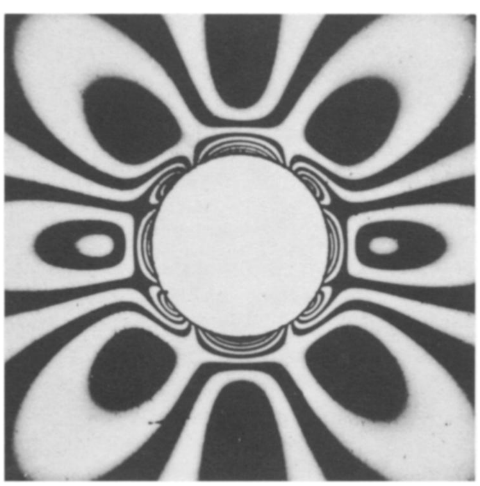

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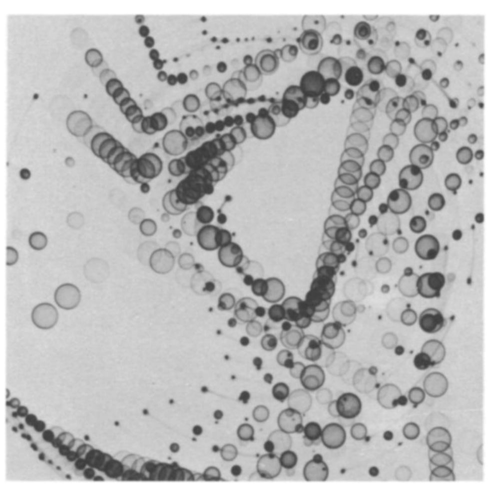

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color with the play of highlights and shadows. They offer us a substantially different experience with every change in lighting, every shift of wind, every change of distance or direction on the part of the observing eye.

Seurat's paintings glow with a lustrous radiance as pulses of color stream from its surface and bombard our eyes. Just as the patter of rain blends into a soothing cadence, the patter of colors on our retina blends rhythmically into a tonic play of sensation. The luminous image is not formed on the surface of the painting; it is formed inside our eye.

The dynamic interaction of seen colors was known to Leonardo, Goethe, Chevreul and Helmholtz. Such knowledge, as it grew and spread, eventually led to the understanding that there are two ways, two levels, on which colors mix. The mixing of two pigments on the palette does not bring us the experience of color that we receive from the mixing on the retina of the light reflected from those two same pigments.

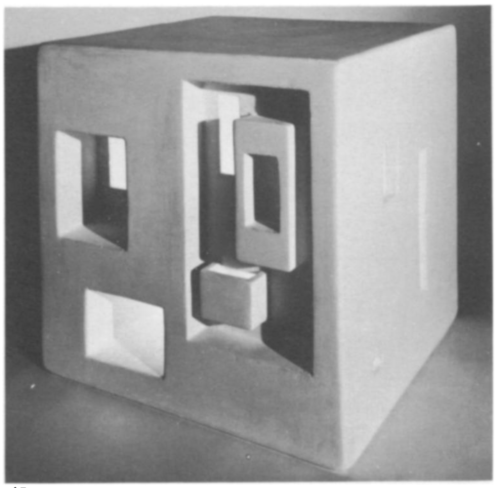
A single class of color sensation corresponds to an extremely large number of kinds of light with varying physical characteristics. Light with identical physical characteristics will produce an identical physiological response: a particular sensation. But identical sensations do not necessarily correspond to identical physical characteristics. For example, the sensation of white, red, green, or any other color can be produced in a variety of ways: a sensation of white may result from the optical mixture of a particular red and a particular green; or from unmixed white pigment; or from the spinning of a color wheel carrying opposite colors. Red and green light reflected by small spots of paint and mixed on the retina will be experienced as yellow, but the same sensation of yellow can also be produced by yellow pigment.

Goethe wrote about "induced" colors and drew the inference that one portion of the retina modifies the sensitivity range of

45 An opaque white perforated cube was illuminated
46 in two ways: first by a single outside source and second, by a single inside source. Each illumination condition produced a different spatial illusion of the same form. The first gives the clearest rendering of the volume, while the second shows some less recognizable areas. Study from M.I.T. Visual Design Course.

47 Two views of a light study: modular opaque
48 shields are placed in front of small windows and lighted from front or back to produce a richly animated surface. Studies from M.I.T. Visual Design Course.

49 A surface composed of highly-polished aluminum
50 modular units photographed under various illumination conditions. Gyorgy Kepes, 1965.



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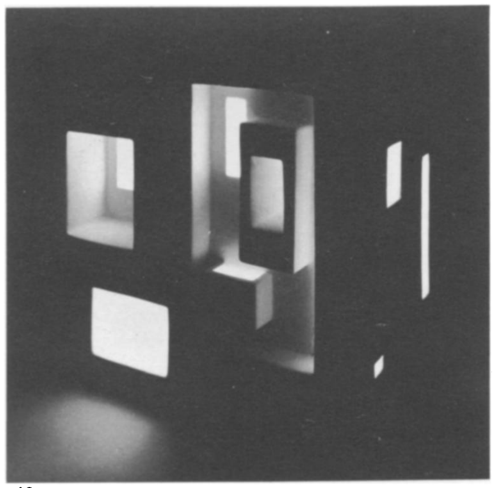

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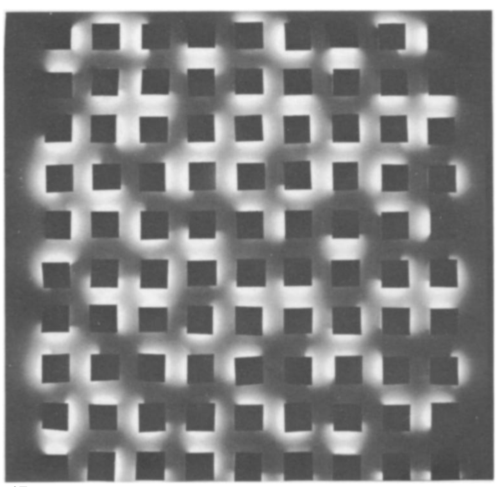

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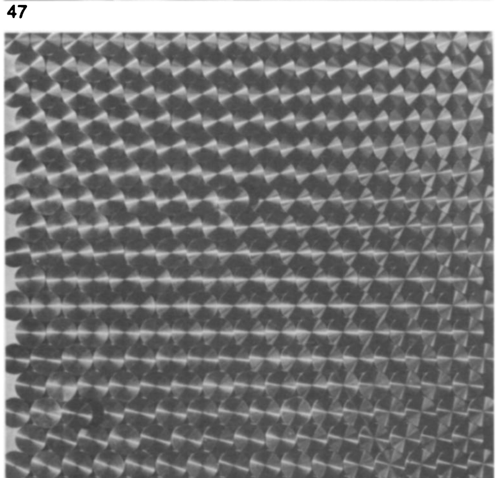

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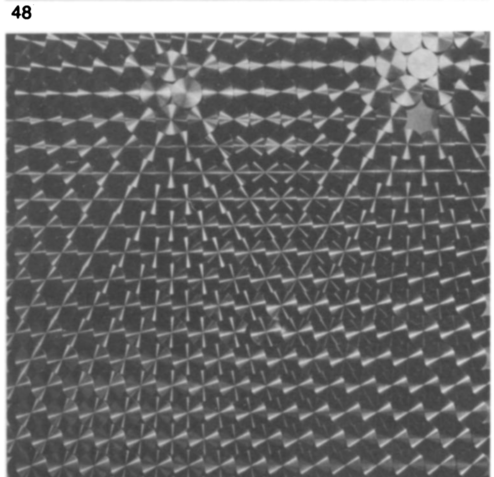

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another. Such modification takes place when impacts are simultaneous as well as when they are successive. (Colors are induced on the retina not only through optical mixing of colored light, but through effects of contrast, both simultaneous and successive.) When we stare at a colored shape for a while and then turn our eyes in another direction, we see an afterimage of the previously-seen colored shape. We see dark after light, red after green, blue after yellow. A probable explanation of this phenomenon is that the receptors of the retina on which the color pulses impinged became fatigued and their sensitivity reduced. The color receptors of the unexposed areas, because of their undepleted vigor, were able to send strong messages to the brain.

After first looking at an intense light and then turning toward a surface that is half white and half black, the eye perceives a blue-green-yellow sequence on the white half, and a yellow-purple-blue sequence on the black half. Thus, a sensation of color may be generated within the eye that has been previously exposed to white light only. Another phenomenon can be observed when, in subdued daylight, a lighted candle is so placed that a pencil intercepts its light and casts a shadow on a sheet of white paper, the shadow cast by the candle appears blue and the shadow cast by daylight appears yellow.

All these phenomena are related; they have a common explanation. The eye, when a color is received, is mobilized to form, unconsciously but inevitably, another color impression—the remainder of the spectrum. Together, the original color and the induced color contain the whole color circle.

Seurat created an intensely living surface by constructing his pictures in innumerable small dots of color, placing them side by side to create areas composed of dots of two or more colors. The color patches, seen from far enough away, blend on the retina; they become more luminous than the original colors. As we move closer, 51 Optical texture created by surface tension produced by mixing different liquid substances. Greatly magnified. Jekabs Zvilna, 1964.

52 Church window in St. Remy de Baccarat. Designer: F. Stahly. The sculptured concrete mullions blend the sharp contours between the light and dark areas.

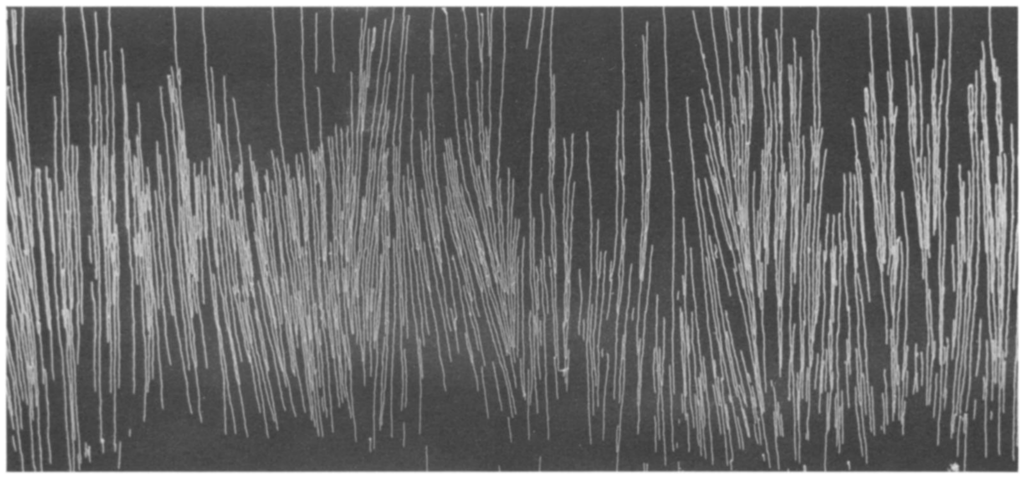
53 "Design Number 2," modular sun screen made from units of perforated light buffers cast from concrete serving to separate as well as to link illuminated and non-illuminated areas. Designed by Ervin Hauer.

the juxtaposed dots of color separate, and they begin to contend with one another. The contention is most vehement when adjacent dots are opposite in color; they lend reinforcement to each other. Red appears redder, green greener. Each movement we make toward or away from the painting alters the quality of the color interaction.

Sir David Brewster has described an experiment that has some bearing on these matters: "If a wallpaper is selected with a pattern which repeats itself at intervals of a few inches, it is possible after some practice, so to arrange the eyes as to cause the adjacent and corresponding portions to seem to coalesce and form a new picture, which will in most respects be identical with that obtained by ordinary vision. This new picture will not seem to be at the same distance from the eye as the real objects, and will move with each slight motion of the head; but it has a certain appearance of transparency and beauty not found in the original. In this experiment two slightly dissimilar masses of light are presented to the two eyes, and the result is an appearance of transparency, using this word in its artistic sense."[5]

Cezanne, another major nineteenth-century painter, enlisted still other characteristics of the light-modulating eye. The lens of the human eye would not be able to bring light of different color from equidistant sources into sharp focus at the same time—rays of different colors are refracted at different angles—if the eye did not compensate by changing the curvature of the crystalline lens correspondingly. The lens must be compressed more to bring red into focus than blue the same distance away.

The extent of eye-muscle strain necessary to bring a color into focus is a function of its distance from the eye. The strain varies inversely with the ostensible distance: the greater the strain, the shorter the distance. Color, thus, has spatial implications: colors advance or recede. The principles governing the phenomenon of



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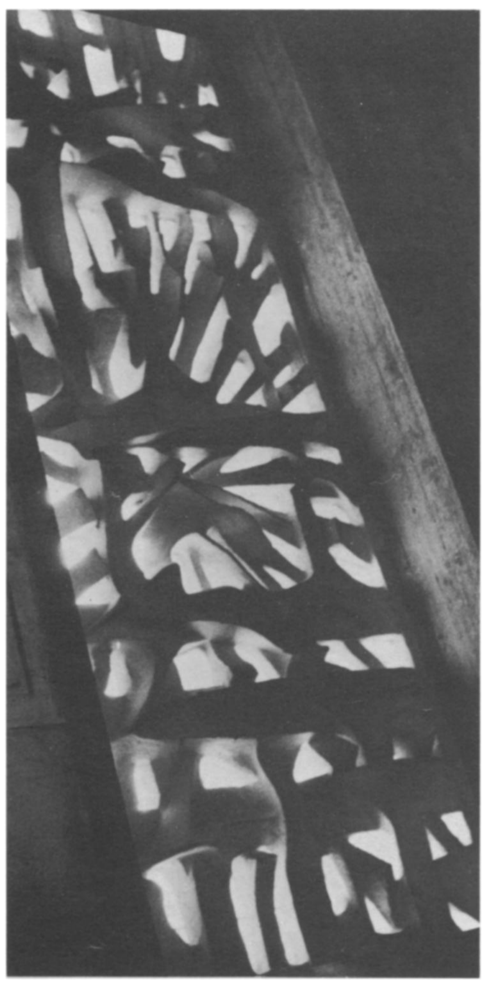

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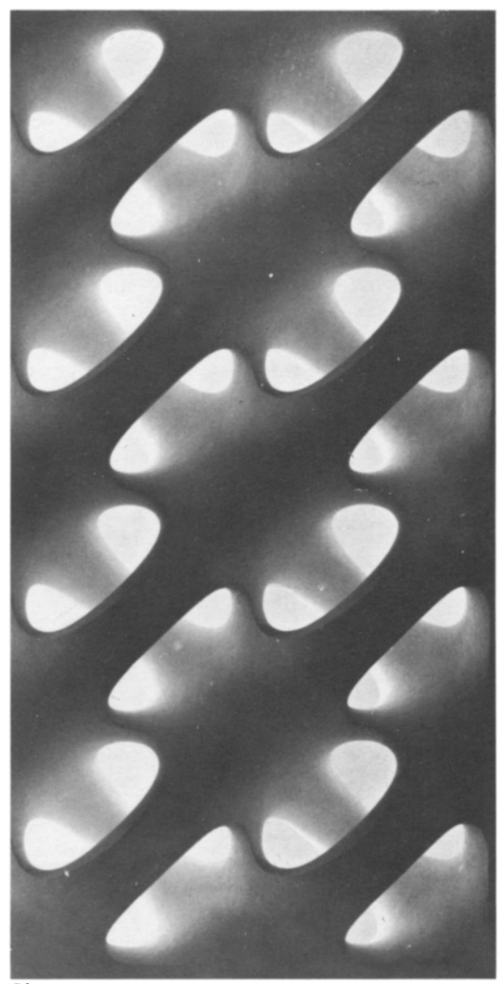

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54 Optical distortion by refraction. A geometric pattern photographed through various types of textured glass. Study from M.I.T. Visual Design Course.

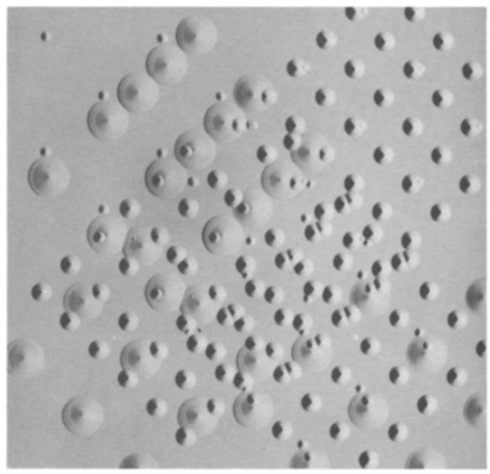
55 56 By tooling a transparent material, the worked areas change their optical characteristics from light refracting to light reflecting. Designed by Paul Talman.

57 "Flight" by Richard Lippold, 1964, Pan Am Building, New York.

chromatic aberration were long studied by Cezanne and applied to the building of a new type of spatiality.

Unlike Seurat, Cezanne dreamed of spaces tenanted by forms with solidity, weight and tension. He wanted to produce a field that was firm and dense, not loose and porous. The separation between the volume of the atmosphere and the volumes of the forms was to be well-marked. Accordingly, he renounced procedures by which dots of color were made to mix additively on the retina of the eye. But he rebelled at returning to the age-old practice of modeling form by a patterning of light and shade, for it made of color an exterior embellishment applied to forms. He said over and again that a pictorial statement about space must not be a mere reproduction of local colors and shadow patterns.

And so Cezanne laid pigments on canvas not as small dots but as areas and patches of some size. The human eye could not mix the colors additively on the retina; the patches were too big for that. As we look at his paintings, the discrete patches of pigment—precisely formulated, carefully tempered and graduated for distance indication, and placed on the canvas with sensitivity and discipline—are integrated by the inner action of our eyes into an impressive, living unity of volumes, masses and energies. The virtual motion of the



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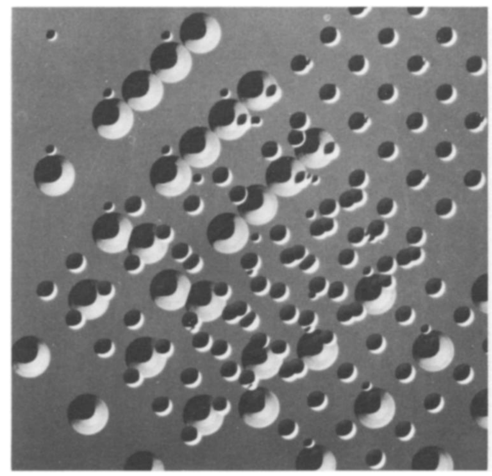

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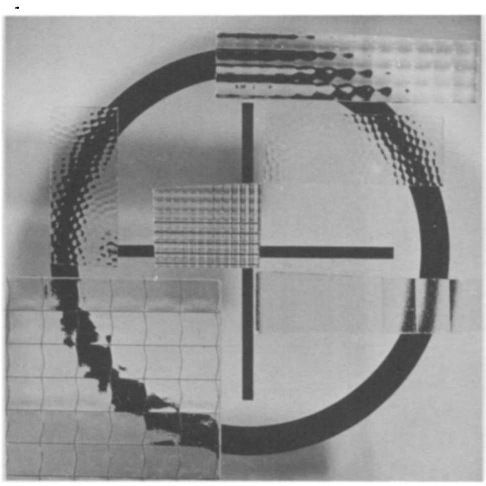

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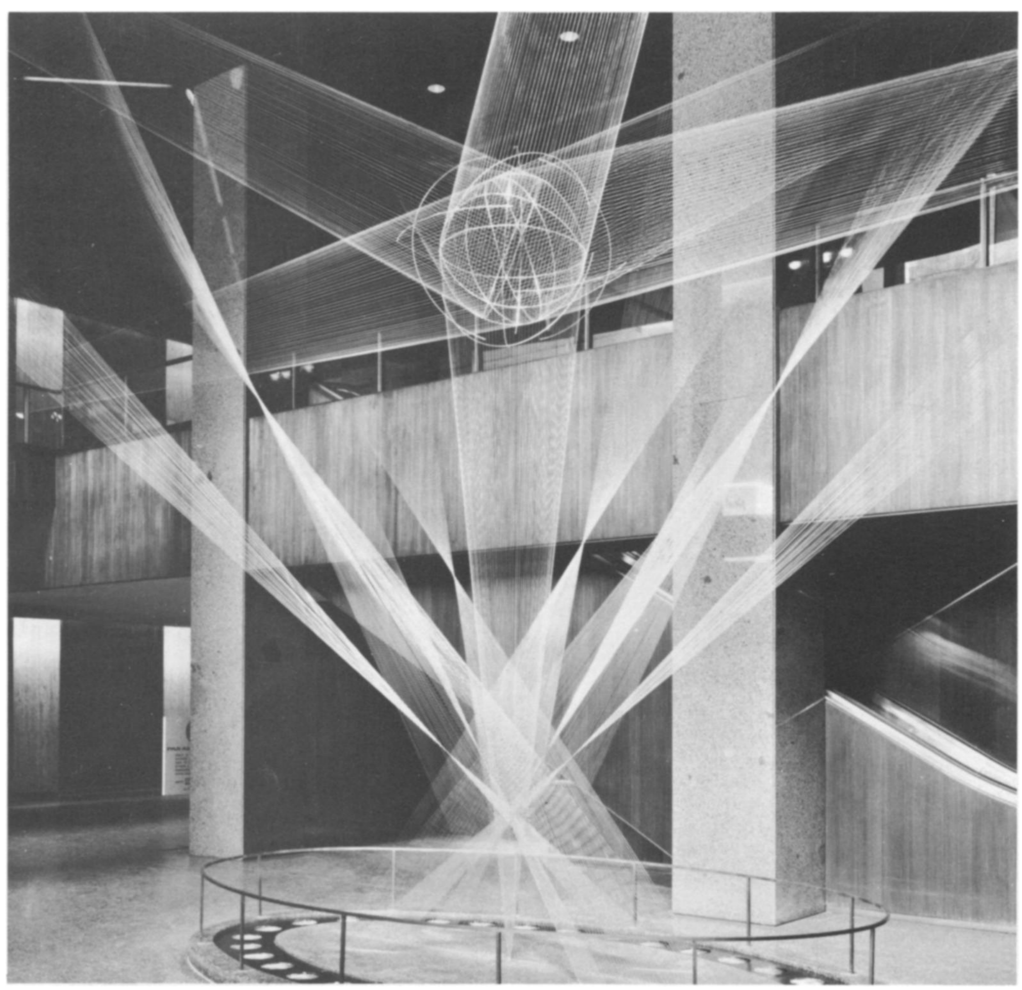

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58 Projections during "Sensations 67" at Dayton's, Minneapolis.

59 Computer data presented on an oscilloscope.

60 New York City nightscape.

61 Photo-elasticity record of pressure diagram. Prof. William M. Murray, M.I.T.

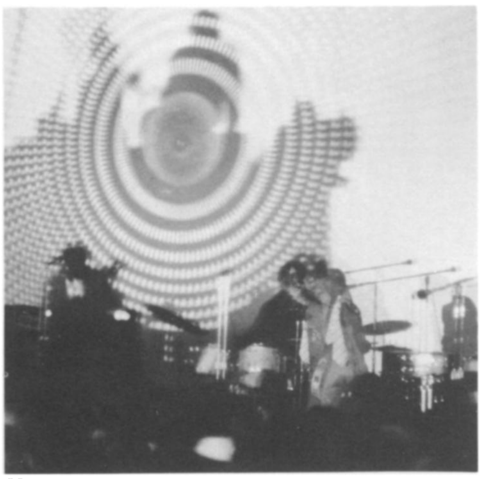
62 Sequence record of moving light reflections from a sculptural screen made up of freely-hanging, highly-polished metal bands. Study from M.I.T. Visual Design Course.

63 Electric light display, New York.

64 Three catalytic crackers; Standard Oil Refinery, Baton Rouge, La.

65 Airport, Washington, D.C.

66 Computer pattern, produced at General Electric Laboratories, Cambridge, Mass.



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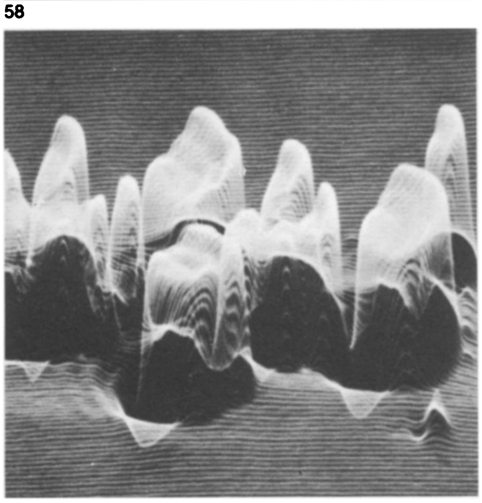

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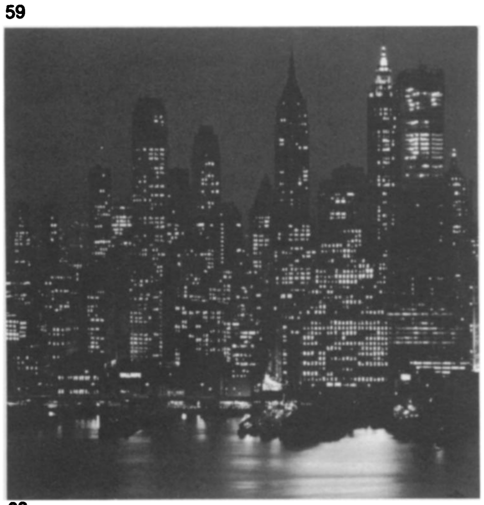

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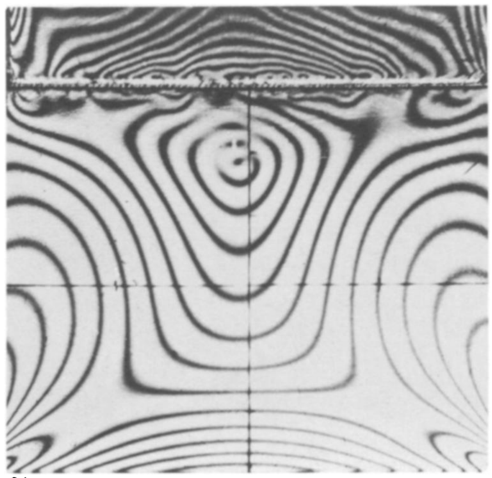

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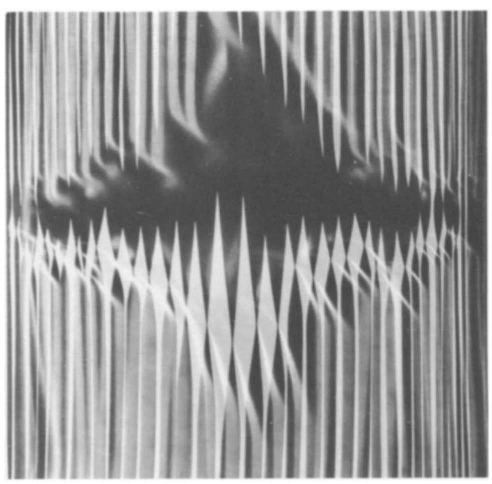

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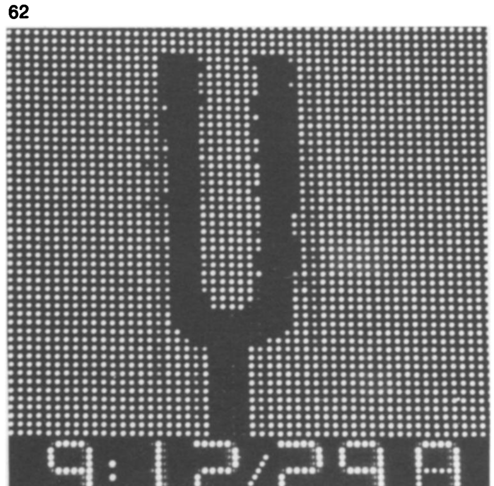

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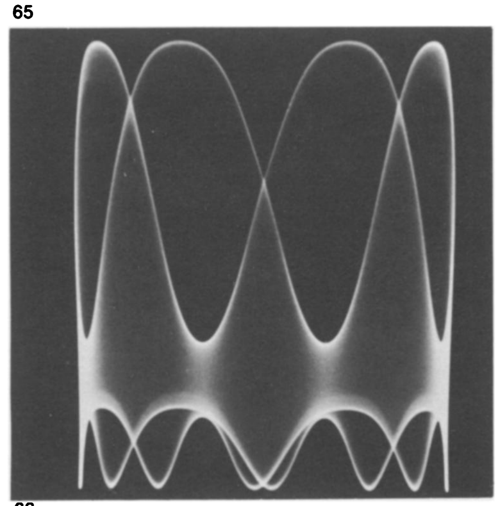

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67 Glass Skyscraper, model, 1920-21, by Ludwig Mies van der Rohe. "My experiments with a glass model of a skyscraper showed me the way and I very soon recognized that the large scale use of glass shifted the issue from light and shadow effects to the play of light reflections." (Comments by Ludwig Mies van der Rohe, in *Frühlicht,* 1922.)

68 Van Nelle factories, Rotterdam, Holland, 1926-1930. Architects: Brinkman and Van der Vlugt.

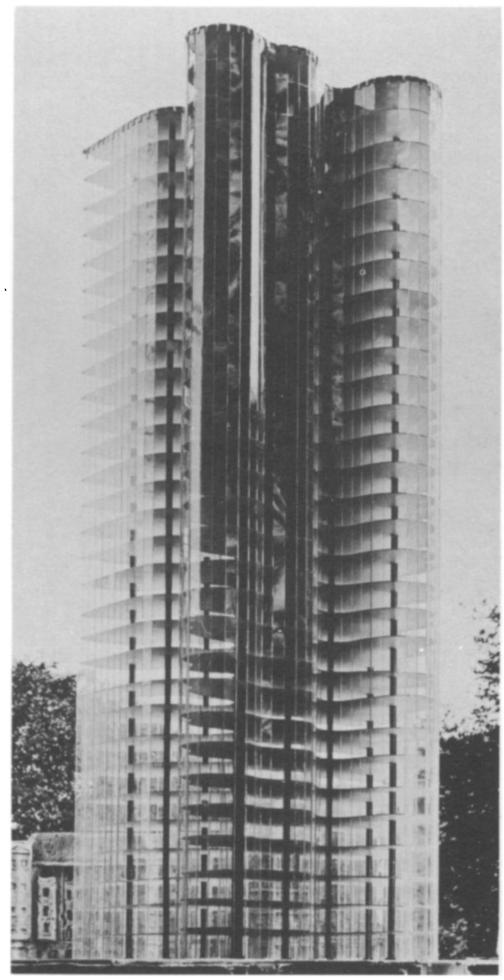
colors has generated within us a sense of a palpable, spatial world. In that spatial world, color is no embellishment of form. Color *is* form—and form is color.

THE CREATIVE USE OF LIGHT IN DESIGN AND ARCHITECTURE

Both natural and artificial light serve as essential, creative tools in a variety of areas. Most of the recent representation and communication devices that are directed to the eye are based on the modulation of light—for example, photography, motion pictures, television, and to some degree, stage design. But beyond this, light has a dominant role in contemporary architecture and the new cityscape. Until now, the use of light has been a neglected area in design. With other means, architects, planners, engineers, and artists have gone far in establishing a basis for a physical environment that is, at its best, authentic in its solution of twentieth-century needs and promising in its enrichment of our lives. While there have been considerable technical advances in lighting, and designers with light have made some notable contributions, there are still many directions that they have not begun to explore nor even begun to dream of.

In large part both the forms of contemporary architecture and the nature of present-day urban life have been modified by technical advances in illumination. The transmission of natural and artificial light through large sheets of glass has helped create a fresh sense of space as well as an augmented demand for light within structures. All hours of the day may now be exploited, for the sharp differentiation in nature between night and day has fused in our cities into a single time scheme of day-and-night. Without artifical lighting in our houses, streets and vehicles, the circulation of people and goods would be reduced to a trickle. When evening comes and the lights are turned on, the city is transformed, however chaotic, blighted or ugly its daytime face. Points, lines, plane figures and volumes of lights, whether steady or intermittent, moving or still, white or colored, whether from windows, signs, spectaculars, headlights, traffic lights or street lights—all compose a fluid, luminous wonder. It is one of the grand sights of our age. Although this impressive display is produced almost by accident, a by-product of utility, it reminds us of the concentrated and ordered beauty of the great windows of thirteenth-century cathedrals. This accidental splendor contains the promise of a new art, the orchestration of light, on both limited and vast scales.

The application of light to clarify and inform architectural spaces and complex cityscapes is not yet a discipline. We do not yet command the principles of the use of light, principles which must be based on a thorough understanding of the tools of lighting as well as on a full awareness of the requirements of lighting in order to raise the art of using light to a high level. Certain preliminary steps must be taken. We know how to make illumination both adequate and comfortable. This has been the goal of illumination engineers who have learned all that physiology and physics can teach them concerning both natural and artificial lighting. But architects and planners realize that there are immense opportunities in lighting, and they demand more than just comfort and amplitude. Stainless steel, reinforced concrete, extensive glass surfaces, and the new structural systems naturally collaborate with the tools of lighting. Together they suggest a whole new range of light qualities for architectural surfaces and spaces, analogous to the way the glass sheath of structures such as the United Nations Building condense and abstract from their surroundings by reflecting the daytime sky and cityscape. No one as yet quite realizes, however, how to take full advantage of these opportunities. Such knowledge will slowly grow. On the other hand, it is possible that a striking advance can be brought about by an effort directed at exploring light itself as a field for the creative imagination, not merely as an adjunct of architecture and planning.



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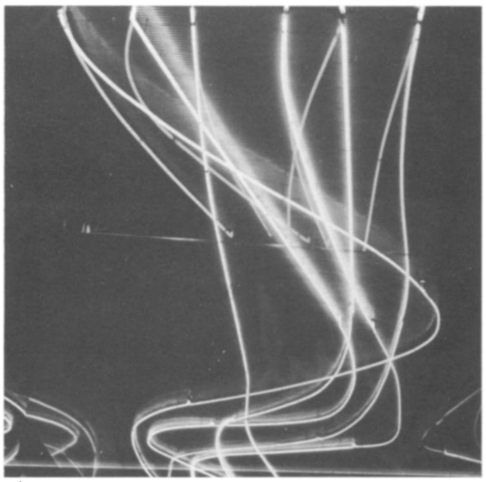
69 Linear display, direction-suggesting: artificial light sources such as these glass tubes of cold cathode lights are formed in various shapes and dimensions thus creating intricate linear patterns of light. By echoing the luminous lines with mirroring surfaces, the visual effects are further amplified.

70 Book display with light fixtures as directional element. Designed by Ashley Havinden.

71 Random patterns of recessed ceiling fixtures, Thorn House, London. Architect: Sir Basil Spence.



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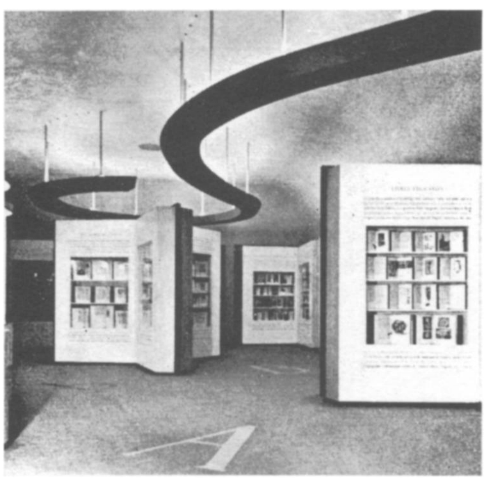

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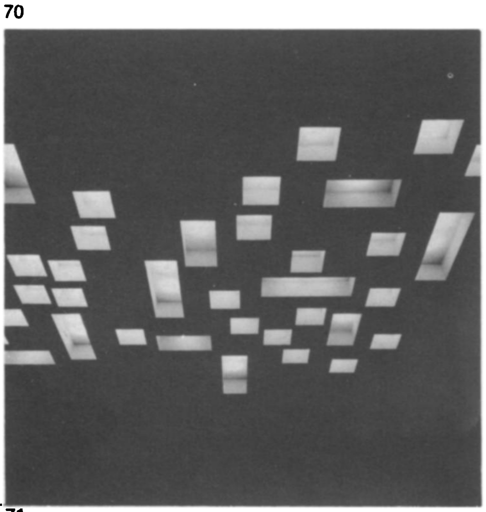

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By a coordinated exploration of the use of light in research areas that are at present unassociated, we shall move toward those fundamental principles that can fully mobilize the designer's artistic sensibility and technical knowledge. We are able to perceive a higher unity achieved in the traditional systems of working with light, as for example the earlier-mentioned techniques employed in the twelfth- and thirteenth-century stained glass at York, Chartres, Le Mans, Sens and the Sainte Chapelle, or in the vibrating play of light in the glass mosaics of Ravenna. We can see the same thing in the sculptural modulation of simple buildings, both ancient and modern, in the Mediterranean basin where there is an unsurpassed use of sunlight to define form and enhance surface; or in the exploitation of mist and gray skies in the looming features of central European castles, or in the Praxitelean use of multi-faceted cutting of Parian marble to make the surface of a statue "breathe." We can see it in the use of light in modern stagecraft and photography, in advertising displays, in the electronic instrumentation of light, in projected light plays and electronically-controlled lighting devices.

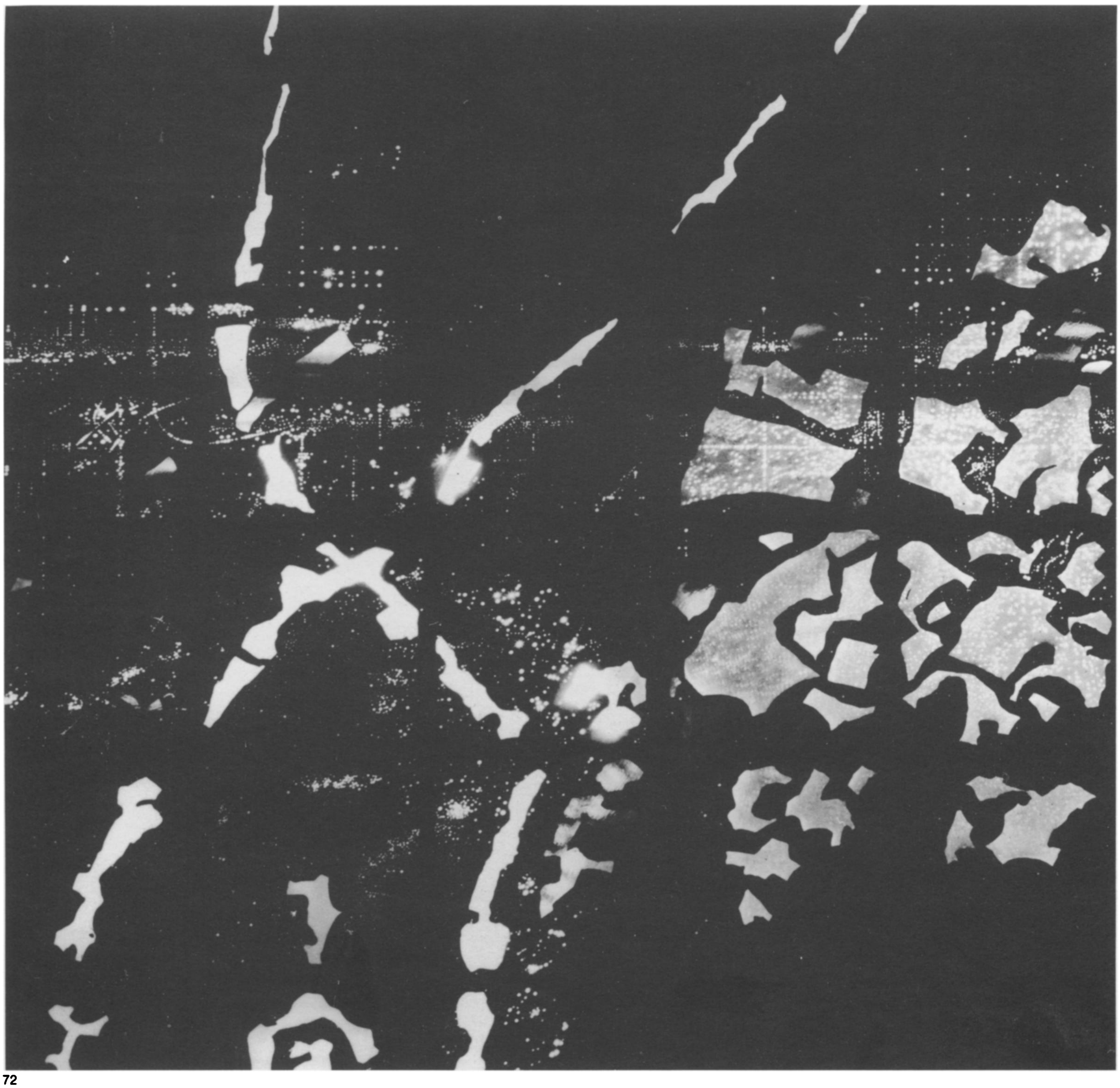
All the forms of light have in common certain principles, and these principles must be developed and exploited for ever wider purposes. Albert Michelson, the first American to receive the Nobel prize in physics, recognized the new scientific and technical dimensions of the twentieth century as legitimate tools and goals for artistic expression. He wrote:

"Indeed, so strongly do these color phenomena appeal to me that I venture to predict that in the not very distant future there may be a color art analogous to the art of sound—a *color music,* in which the performer, seated before a literally chromatic scale, can play the colors of the spectrum in any succession or combination, flashing on a screen all possible gradations of color, simultaneously or in any desired succession, producing at will the most delicate and subtle modulations of light and color, or the most gorgeous and startling contrasts and color chords! It seems to me that we have here at least as great a possibility of rendering all the fancies, moods, and emotions of the human mind as in the older art."[6]

Artists a generation before us also recognized the need for a new frame of reference for their creative vision. They sought new ways to project their responses to the new possibilities. Painters, photographers and filmmakers struggled to find valid new idioms with which to bring space and light into a vital focus. Magnificent artistic statements were made with pigments on canvas or recorded with light on photosensitive film. These artists were, nevertheless, frustrated and tantalized because the limits of their media narrowed and condensed the explosive range of the new experiences—needed were a new scale of tools and a new scale of setting. Only by accepting light as autonomous, as plastic luminosity to be molded, shaped and formed with the same limitless plasticity as the sculptor's clay, could the artist hope to find a valid correspondence between his new scale of experience and his artistic expression of it. Only a spatial surrounding generous enough in scale to shelter the explosive luminous tools could provide an adequate background. The isolated, sheltered, small space of a room in the home or in a museum is suffocatingly narrow for the fluid power of light in action. The new, rich intensities of artificial light sources, if used creatively must be woven into the bigger fabric of the night cityscape. The mirroring of the shop windows, the interpenetration of mobile vistas, with their continuous transformations of space and form, must be accepted as background to creative figures shaped by the moving contours of actual lights.

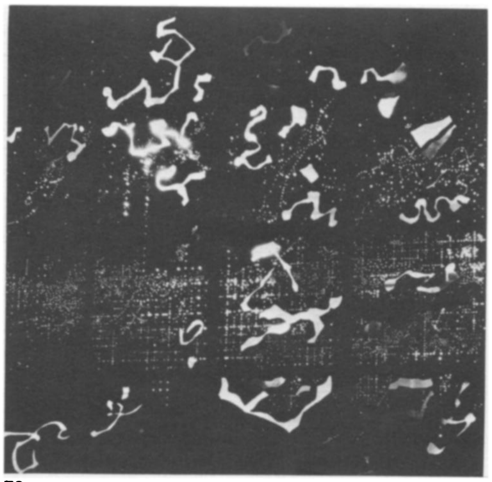
An example may be useful here. The opportunity to try out these new tools in their new setting was given to me some years ago by a commission for a mural in the offices of a leading airline in the heart of New York City. The theme was the rich-

72 Detail of light mural for K.L.M. office, New York, 1959. Designer: Gyorgy Kepes.



73 Detail of light mural for K.L.M. office, New York, 1959. Designer: Gyorgy Kepes.

74 Research tower of S. C. Johnson & Son, Inc., Racine, Wisc. Architect: Frank Lloyd Wright.



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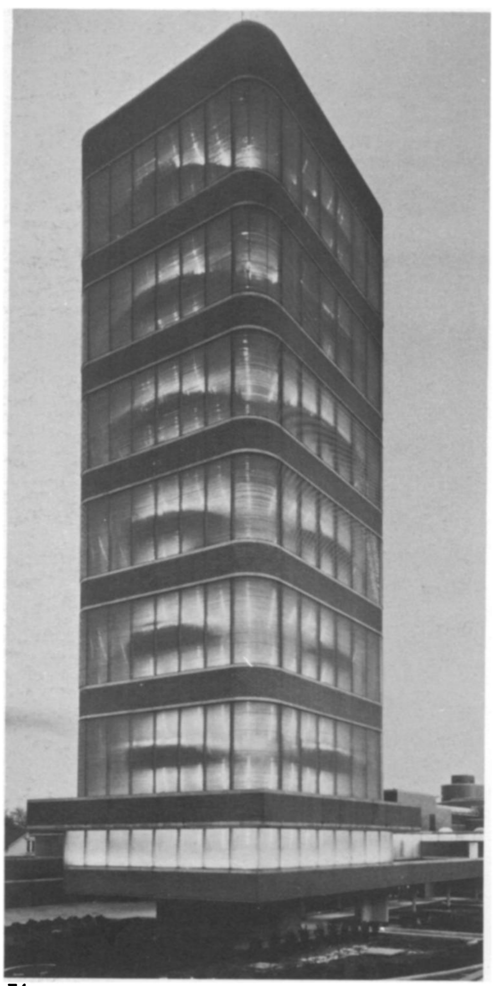

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ness of the appearance of the nocturnal city from the air. The tool chosen was light in action. The mural, over fifty feet long and eighteen feet high, is a gray aluminum screen with some sixty thousand random perforations and larger cutouts. The sources of light are a multitude of incandescent, fluorescent, and spotlight bulbs and tubes behind the mural surface, controlled by timing and switching devices that actuate the circuits. The purpose was to create, by means of these devices, a fluid, luminous pattern with random changes, alive through the continuous transformation of color intensity, direction, and pattern. To avoid the mechanical repeat inherent in a mechanized device, many thousand different color filters were placed behind the perforations in random distribution. The underlying design idea was based on the principle used in Peruvian fabrics: maintenance of rhythmic interplay between a constant pattern and a changing pattern. On the one hand—on the permanent pattern of the perforation—a shifting color scheme was superimposed, and on the other hand—on the recurring time pattern of brightness—were superimposed cutouts and perforations varying greatly in shape and linear direction. By such means, I tried to meet some of the older reservations about the justification of a mobile visual art form as expressed by Wilhelm Ostwald:

"According to this reasoning the legitimacy and the explanation of discords in the art of music depend upon the temporal sequence of concords. Is there anything comparable to this in the art of color? The answer is a very decided and fundamental "No," for the art of color—at any rate in its present-day condition—is totally destitute of the temporal element. A discord which has been introduced into a picture, woven into a carpet, or printed on a wallpaper has to remain there, forever unresolved. It is not permissible to say that we can place the resolution beside it. There is nothing to compel the eye to look at the discord first and then at the resolution, for the exact opposition is just as likely to be the case."[7]

Although the mural has a defined architectonic role in the design of the office, which is on the street level, the intention was to make it part of the large space of the street outside, sometimes blending and sometimes competing with the rivers of light generated by moving automobiles, giving and taking light from the surroundings, both invading the outside space and being invaded by it.

Another example which shows the imaginative teamwork of a group involved a designer and painter, a sculptor, a structural engineer, a lighting consultant, and an architect and planner. This team addressed itself to the problem of providing a major, aesthetically and functionally, valid landmark for a large city on the eastern seaboard of the United States. The description that follows renders part of the joint report that outlines their plans, as recently submitted to the city authorities.[8]

"A central gathering place for all the activities of the downtown part of the city is a park surrounded by the city's newest and tallest buildings. Night and day the area is a thoroughfare for businessmen, shoppers, visitors, and pleasure-seekers. Because of its location at such an important point in the life of the city, it was clear that plans for this site must envisage something more than a mere expanse of paving and shrubbery. Trees, benches, and paving stones can identify an area as a park; but to serve as a true landmark, to invite to relaxation, to intensify its character as a reference point for both resident and visitor, a park must have a dimension, a distinctive significance, which truly sets it apart as a special place."

To achieve the desired effect, the planners in this case proposed a Tower of Light, to be located at one corner of the park, outside a paved ellipse. Thus the tower would enjoy maximum visibility and lighting effect from a nearby bridge and an elevated walkway, as well as from a large part

75 Entrance of the Montecatini Exhibition at the Milan Fair, with moving neon writing, 1958. Designer: Heinz Waibl.

76 Ceiling of the Pallazo dello Sport in Rome.
77 Perforated concrete ribs create this huge dome with lighting integrated into the structure. By day the focus is on the center opening while at night the strings of fluorescent tubes create a pattern of light and dark. Designer: Pier Luigi Nervi.

78 Exhibition hall, Turin, Italy. Designer: Pier Luigi Nervi.

79 Chapel of Unity, Coventry Cathedral, Coventry, England. Architects: Sir Basil Spence & Partners.

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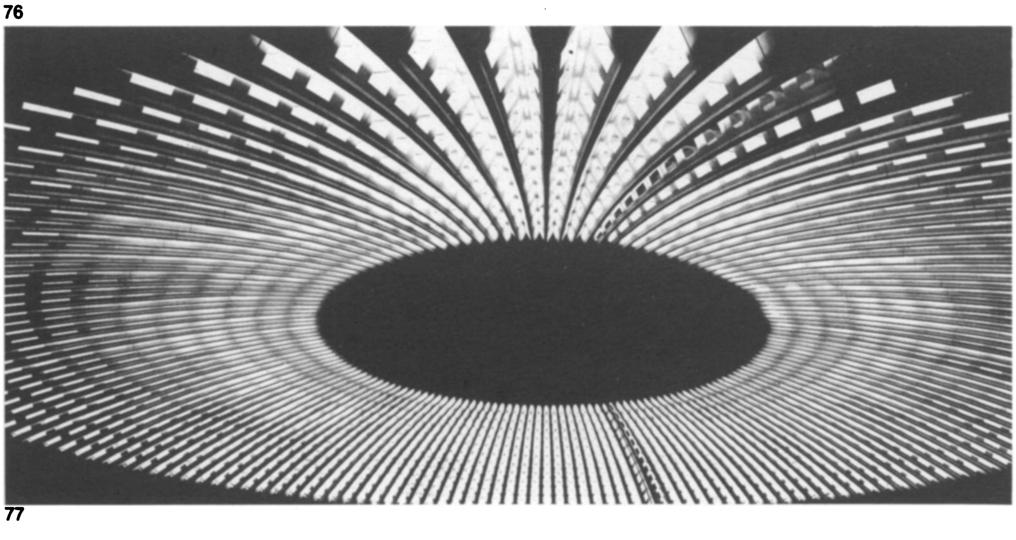

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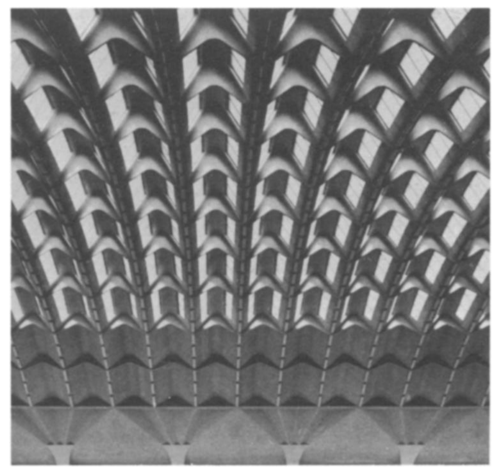

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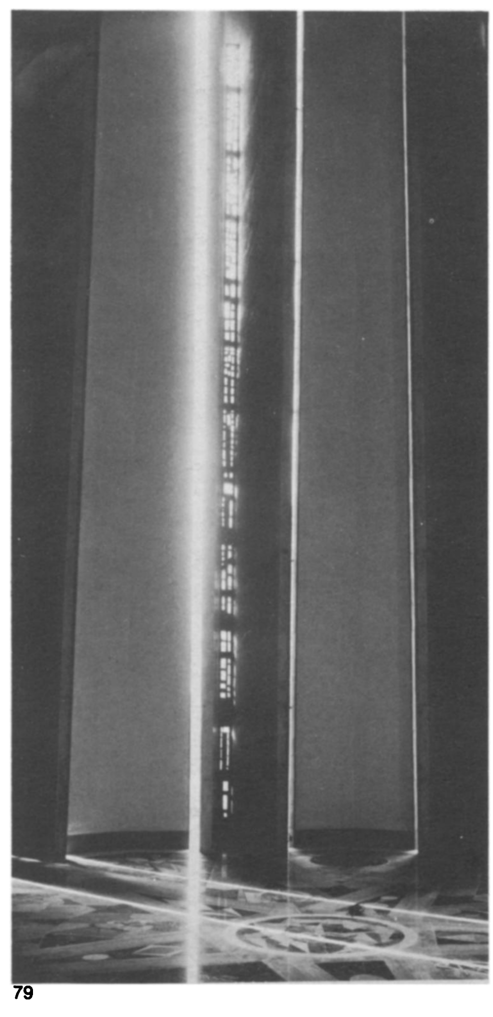

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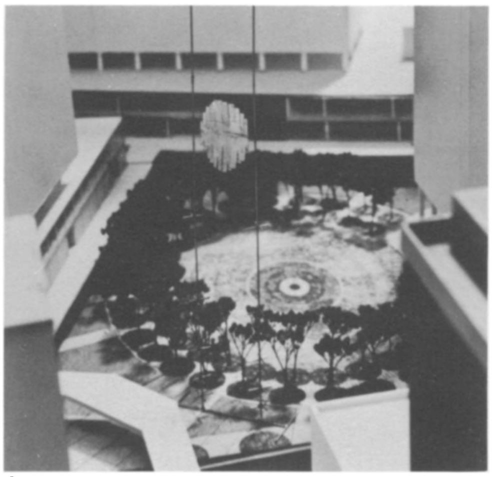
80 Model of Charles Center, Baltimore, Md. with "Light Tower." Design team: Gyorgy Kepes, George Kostritsky, William Wainwright, William Lamb and Michio Ihara.

81 Model of "Light Tower."



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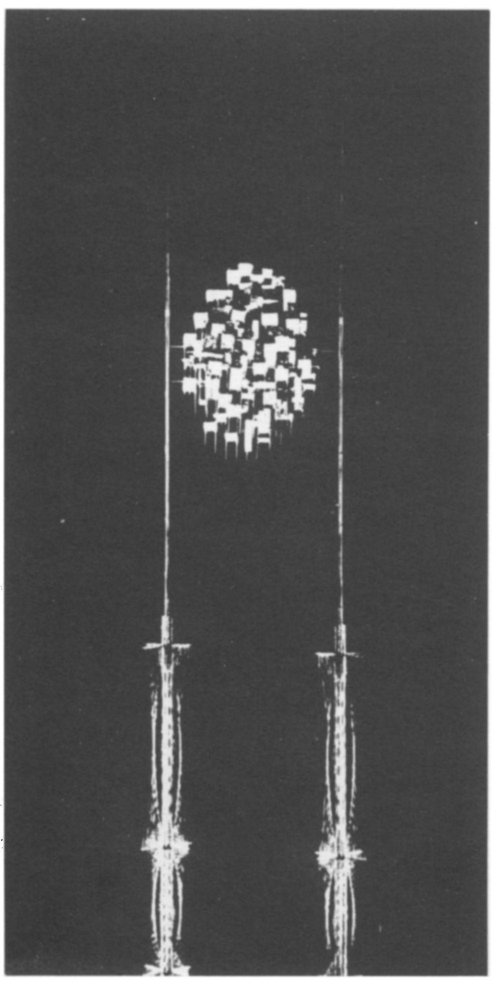

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of the central downtown area. On the Tower of Light is to be a 25-foot-wide reflective screen suspended 100 feet above the park. At night, the many facets of this screen, covered with bright, durable gold leaf, will arrest the rays of a powerful light from the pool below and reflect them back down upon the entire park area. By day, reflected sunlight from the plaza and buildings picked up by the screen will bring to life the warm surface of the man-made sun.

Set in a shallow pool of water, two 160-foot towers of steel cable spun over a slender frame support the elliptical disk. The towers are set 30 feet apart and are securely anchored to the concrete structure of the parking areas below. The deceptive slimness of the mast, spreaders, and stainless steel filaments hides strength known to builders of sailing craft for years but never before so purely applied to an architectural problem. Pound for pound, the towers far exceed the strength of the steel frames in the tall buildings that surround the plaza.*

At night a cluster of powerful lamps, totaling 25 kilowatts, will direct a beam of light straight up into the air. The gold-leafed disk will scatter most of the reflected light back down upon the plaza, but portions of the beam will escape, creating slim shafts of light above in the night sky. The actual light elements will be contained in cone-shaped islets rising from the center of the pool. By day the reflective surfaces, pointing northeast away from the sun, will glow with light reflected from the windows of the surrounding office buildings. In contrast to the disk, the masts and cables will show a dark metallic luster. One will see them against the background of sky and glass as a tense, sharp network. Thus the impact of the Tower of Light will lie not in bulk or monumentality but rather in its freshness and ingenuity, a spirited symbol of the energy of the new city.

The tower represents an opportunity to use typically twentieth-century forms and materials to produce, by imagination and technology, a solution to an urban problem. The problem of handling a small square at the nerve center of a city, set about with tall buildings, exists today on a scale more vast than ever supposed in any previous age. Of course there have been other light towers designed before, but they were mainly for a functional, decorative or publicity purpose. This design is different in several essential ways. First, it is not an entity in itself, but an essential part of an integrating factor in a city area—the plaza. Each architectural, spatial form has a day and night life, the two frequently without any consistency. During the day, the legibility of the buildings and their interspaces is based upon patterns of light and shadow formed by a single light source—the sun. At night, however, the original unity of the buildings and their spatial community is shattered by conflicting interior and street illumination. To counteract this destruction of spatial unity, the light tower was designed to be another central light source, which could restore the legibility of a single pattern of light and shadow instead of a wild jungle of intercepting shadows produced by a multitude of lamps. Indeed, the single light source could serve somewhat as a fireplace in a living room. The gold-leafed, light-reflecting screen will give a warm

*One of the advances in metallurgy which enable the engineer to make radical refinements in the designs of yesteryear is the availability of high-strength steels. For masts and spreaders it is no longer necessary to design to working stresses of 20,000 per square inch (psi). Bethlehem Steel Company now manufactures its V65 steel with a yield point of 65,000 psi and a tensile strength of some 80,000 psi. U. S. Steel's T-1, with a different set of properties, goes even beyond this. Bethlehem also manufactures a highly corrosion-resistant steel by the name of Mayari-R which does not require painting to retain its strength. With a choice of such finely engineered materials, the designer is in a position to do things with his structure that were unheard of only ten years ago. Similar considerations apply to the specification of powerful low-voltage light sources.

82 Ceiling at S. C. Johnson & Son, Inc., Racine, Wis. Architect: Frank Lloyd Wright.

83 Yale University Art Gallery, New Haven, Conn., 1951-53, showing ceiling made of concrete tetrahedrons. Architect: Louis I. Kahn.

84 Ceiling at the Whitney Museum of American Art, New York City, 1963-1966. Architects: Marcel Breuer and Hamilton Smith.

85 Richards Medical Research Building, University of Pennsylvania, Philadelphia, 1957-1961. Architect: Louis I. Kahn.


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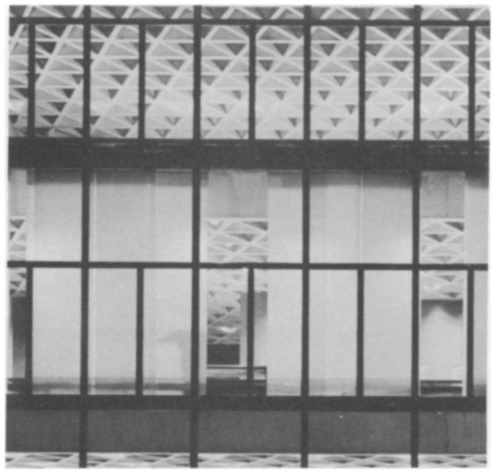
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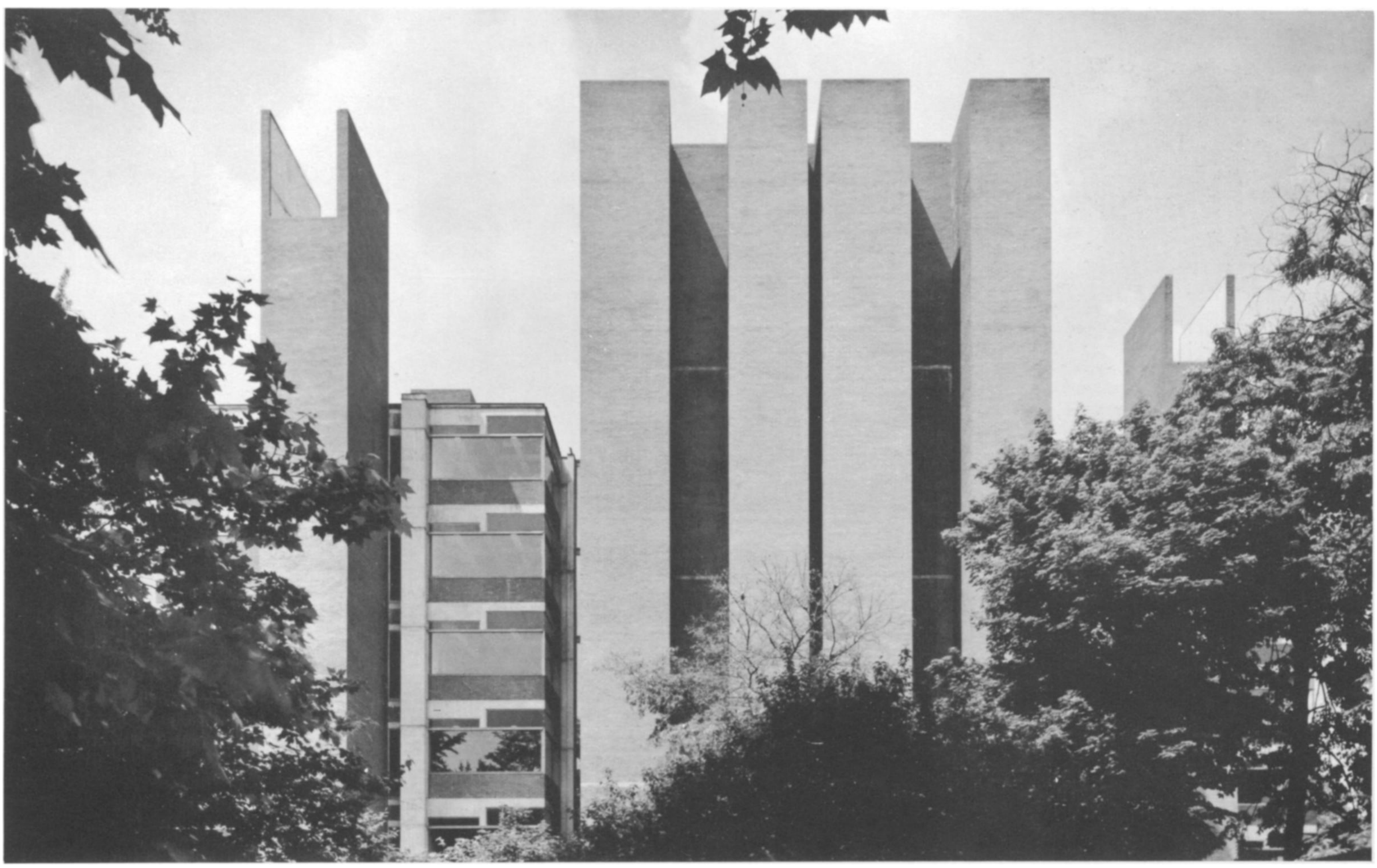
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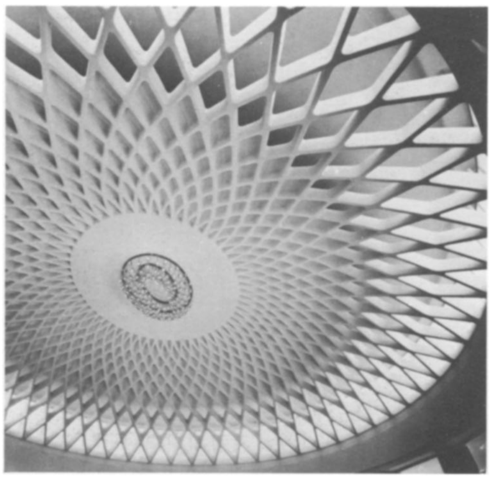
86 Thermal Center, Chianciano, Italy. Designer: Pier Luigi Nervi.

87 Wells Fargo Bank (Crown-Zellerbach Office), San Francisco. Architects: Skidmore, Owings & Merrill.

88 Chapel of Unity, Coventry Cathedral, Coventry, England. Architect: Sir Basil Spence & Partners.

89 United States Air Force Academy, Colorado Springs, Colo. Architect: Skidmore, Owings & Merrill.



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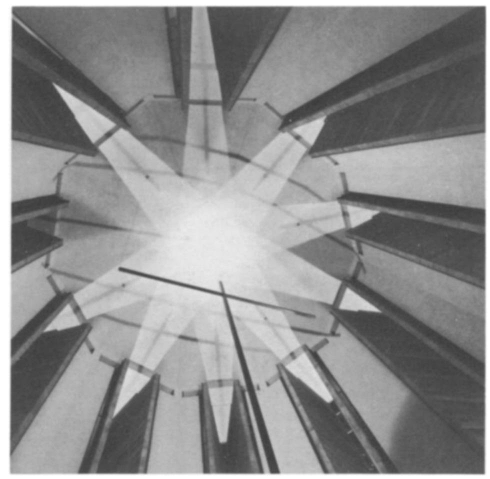

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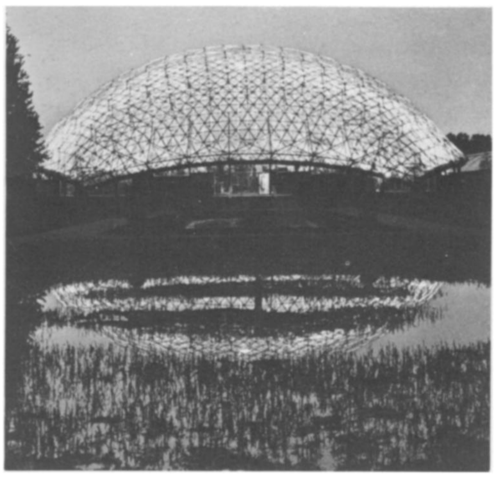
90 Climatron, Missouri Botanical Garden, St. Louis, Missouri. Designer: R. Buckminster Fuller.

91 Stainless steel screen designed by Michio Ihara for The Imperial Theater, Tokyo.

92 Grand staircase, Metropolitan Opera House, Lincoln Center for the Performing Arts, New York. Architect: Philip Johnson.

93 Light fixture made from transparent plastic rods acting as light conductors. Rohm & Haas Office Building, Philadelphia, Pa., 1963. Designer: Gyorgy Kepes; collaborator, Michio Ihara.



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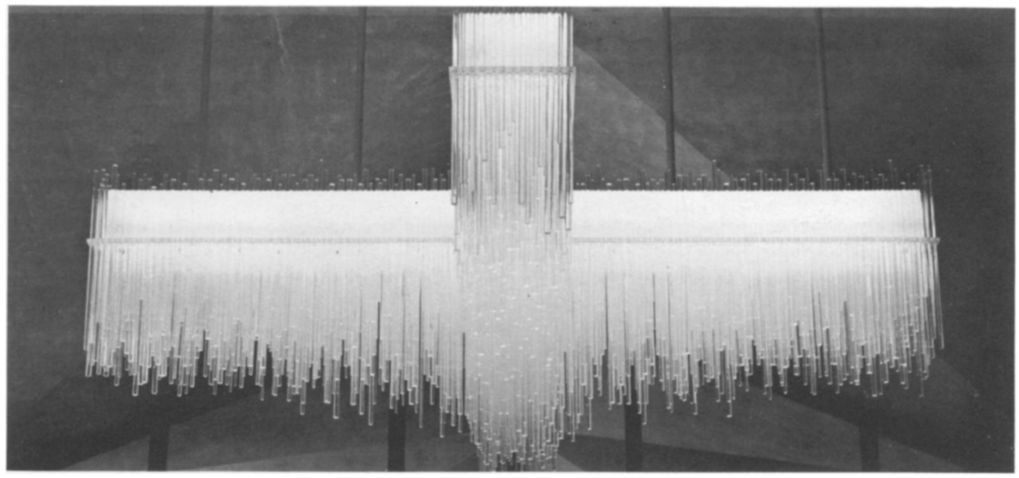

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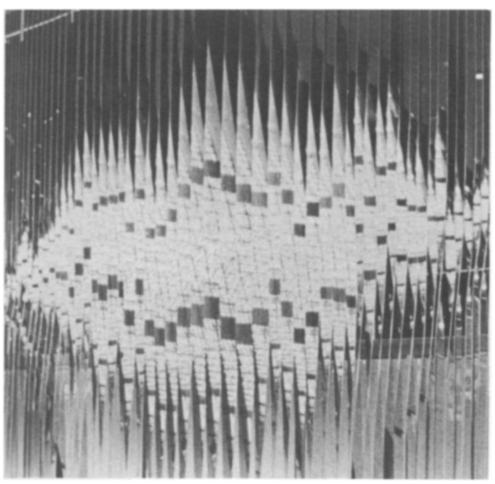

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glow of changing patterns and thus recall the never-resting richness of the fire on the hearth, a constant central symbol in the increased scale of man-created environment.

The second consideration in designing the tower was the awareness that each historical stage has had its preferred technical tools and that the most potent artistic imaginations have always utilized the most advanced technical potentials. The stained glass of the thirteenth-century cathedrals and the Crystal Palace of the nineteenth century are cases in point. Artificial illumination and new structural principles are among the most fertile, potential and creative devices of this century. The tower and the reflecting screen are based upon advanced structural principles. The light sources exploit powerful illumination tools. Together they can stand as a new art form — a luminous sculpture radiating its image far beyond its actual location and function — a part of the total cityscape, a landmark.

On a smaller than the urban scale, there are possible pictorial and sculptural uses of light, the use of luminescence, or the channeling of light along an elaborate linear path by means of bundled optical glass fibers. Photosensitive glass, color filter overlays, polarized screens, diffraction grating are still other possibilities. Projected light could be explored in terms of its kinetic-graphic potential as used in animated films and also projections. It could also be utilized in transient murals in which opaque or transparent flat surfaces or sculptural reliefs are brought into common play.

The devices of stage designers suggest other new possibilities. Light could be articulated in its time sequence, and the combination of stroboscopic illumination with stable light sources used to produce luminous animated sculptures.

At a more technical level, optical light and color phenomena could be applied to investigate natural processes. Technical investigation of chromatography, photoelasticity and so forth could be developed on a exploratory basis, without immediate scientific goals, as possible new tools for reading nature. We should remember that at one time use of oil paint or photography was just as "foreign" too, and had to be just as much "learned" by artists as are these new tools for expressing ideas visually.

FOOTNOTES

1. Bragg, Sir William, *The Universe of Light* (New York: Macmillan, 1933).

2. Chevreul, Michel Eugene (1786-1889) French chemist.

3. Rumford, Count Benjamin (1753-1814) American-British scientist and administrator.

4. Young, Thomas, M.D., *"On Vision," A Course of Lectures on Natural Philosophy and the Mechanical Arts,* vol. 1. (London: Joseph Johnson, 1807), pp. 455-56.

5. Rood, Ogden N., *Students' Text-Book of Color; or, Modern Chromatics, with Applications to Art and Industry* (1879).

6. Michelson, A. A., *Light Waves and Their Uses* (Chicago: Chicago University Press, 1961), p. 2.

7. Ostwald, Wilhelm, *Color Science* (London: Windsor and Newton, 1931-33), pp. 162-63.

8. "Charles Center (Baltimore) Tower of Light, Special Study," Rogers, Taliaferro, Kostritsky, Lamb, July 1964 (mimeographed). The team consisted of Gyorgy Kepes as designer and coordinator; George Kostritsky, architectural and planning coordinator; William Wainwright, structural engineer; William Lamb, illumination engineer; and Michio Ihara, sculptor.

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Gyorgy Kepes was born in Selyp, Hungary, in 1906. He studied at the Academy of Fine Arts, Budapest, under Istvan Csok, 1924-1929; M.F.A. 1929, and was a member of the Hungarian avant garde group, MUNKA, 1928-1930. In 1930 he gave up painting for film and went to Berlin where he worked with L. Moholy-Nagy on film, stage, exhibition and graphic designs. He came to the United States in 1937 to head the Light and Color Department of the Institute of Design in Chicago. In 1944 he published *The Language of Vision* (now in its 13th edition), a summary of educational ideals and methods developed while teaching at the Institute of Design. Since 1946 he has been Professor of Visual Design at the Massachusetts Institute of Technology, Cambridge. Interested in the converging contribution made by art and science, he formulated ideas on the images common to our expanding inner and outer world in *The New Landscape in Art and Science* which was published in 1956 and is now in its 3rd edition. Professor Kepes has contributed to various publications and was editor of *The Visual Arts Today* (1964) and also of the *Vision and Value* series: *The Education of Vision; Structure in Art and in Science; The Nature and Art of Motion; Module, Proportion, Symmetry, Rhythm; Sign, Image, Symbol; The Man-Made Object* (1965-66). In recent years he has also designed stained glass windows and murals with mobile light for various public buildings. His designs and paintings have been exhibited in major museums and galleries and are in the permanent collections of many museums in the United States. Professor Kepes lives and works in Cambridge.