education of vision

EDUCATION OF VISION

VISION + VALUE SERIES

EDUCATION OF VISION

EDITED BY GYORGY KEPES

George Braziller, New York

For information address the publisher:
George Braziller, Inc.
215 Park Avenue South
New York 3, New York
Library of Congress Catalog Card number: 65-10807
Manufactured in the United States of America

CONTENTS

INTRODUCTION

Every properly functioning human being transforms the visual signals that he receives from outside into structured, meaningful entities. Without the perceptual ordering of his sense responses into images of things in space, man cannot orient himself. Without shaping his physical environment in accordance with these images, he cannot survive. His capacity to structure his environment according to his needs—that is, his ability to work out a rapport with his world—determines the quality of his life.

Thus, vision, our creative response to the world, is basic, regardless of the area of our involvement with the world. It is central in shaping our physical, spatial environment, in grasping the new aspects of nature revealed by modern science, and, above all, in the experience of artists, who heighten our perception of the qualities of life and its joys and sorrows.

Vision is a key to man's creative power, even on the most rudimentary level. Our eye receives only the random flow of light stimulation; the light rays that impinge on the retina have no intrinsic order. But our dynamic tendency to create order transforms the basic sense impressions of light signals into meaningful forms. From the welter of sensation bombarding the retinas of our eyes, we articulate structures, images; and from the intermingled, interconnecting, shifting stream of optical images, we separate persistent patterns, things, events. Thus to perceive an image is to participate in a forming process; it is a creative act. In the simplest form of visual orientation and in the most embracing unity of a work of art there is a significant common basis: the sorting and organization of sensory impressions from the visual field.

But vision, though the key orderer, nevertheless receives its scope and scale from what it orders. Our visual experiences are drawn from the features of the visible world around us. The strength, the richness, and the order of the visual forms that we create depend, to a certain extent, upon the nature of our visual surroundings. If, in the world, man sees around him the rhythm of nature's processes revealed, and if the colors, forms, and movements he sees are expressions of organic events, then his vision is nourished by the "primal sanities of nature"—to use Walt Whitman's words. If the primal sanities of nature can be absorbed through his vision, if man is led to see them, he can reproduce them in the world he shapes for himself.

Today, we have lost the benefit of these natural guides because we are surrounded by the "second nature" of our man-made environment, an environment that has not grown according to nature but has been shaped by one-sided and shortsighted interests. The appearances of things in our man-made world no longer reveal their character: images imitate forms; forms cheat functions; functions are robbed of their natural sources emanating from human needs. Our cities, our buildings (counterfeit inside and out), objects for use, the packaging of goods, posters, the advertising in our newspapers —even our clothes, our gestures, our physiognomies—are often without visual integrity. The world that modern man has constructed by and large lacks sincerity and scale. It is twisted in space, without light, and cowardly in color. It combines mechanically consistent patterns of details within formless wholes. It is oppressive in its fake monumentality; degrading in its petty, fawning manner of face-lifting. Men living in this environment, injured emotionally and intellectually by the terrific odds of their compassless society, cannot avoid injury to their sensibilities, the basis of their creative faculties.

To give direction and order to this formlessness, we have to go back to our roots. We need to regain the health of our creative faculties, especially of our visual sensibilities. There is a reciprocal relationship between our distorted environment and our impoverished ability to see with freshness, clarity, and joy. Fed on our deformed and dishonest environment, our undernourished visual sensibilities can only lead us to perpetuate the malfunctions of the environment that we create. To counteract this spiral of self-destruction, we have to re-educate our vision and reclaim our lost sensibilities.

The formlessness of our present life has three obvious aspects. First, our environmental chaos, which accounts for inadequate living conditions, waste of human and material resources, and pollution of air, water, and earth. Second, our social chaos—lack of common ideas, common feelings, common purposes. Third, our inner chaos—individual inability to live in harmony with oneself, inability to accept one's whole self and let body, feelings, and thought dwell together in friendship.

We have, then, three basic tasks before us. First of all we must build bridges between man and nature—construct a physical environment which is on a truly twentieth-century standard. Second, we must build bridges between man and man—create a new scale of social structure built from progressive common purposes. We must establish a sense of belonging, of interdependence, in order to achieve the teamwork which the first task demands. And finally, we have to build bridges inside ourselves. Only if each individual can unify himself, so that one aspect of his life will not intercept and cancel another, only by achieving inner freedom, can we hope to tackle the second task efficiently. Only the man who can work with himself can work with other men.

The building of these bridges—the reintegration of all aspects of our life through twentieth-century knowledge and power—is our great contemporary challenge, and in this work the imaginative power of creative vision can have a central role. Artists are living seismographs, as it were, with a special sensitivity to the human condition. They record our conflicts and hopes, and their immediate and direct response to the sensuous qualities of the world helps us to establish an entente with the living present.

The basic characteristic of any artistic expression is the ordering of a visual impression into a coherent, complete, living form. The difference between a mere expression, however intense and revealing, and an artistic image of that expression, lies in the range and structure of its form. This structure is specific. The colors, lines, and shapes corresponding to our sense impressions are organized into a balance, a harmony, or rhythm that is in an analogous correspondence with feelings; and these feelings are, in turn, analogues of thoughts and ideas. An artistic image, therefore, is more than a pleasant tickle of the senses and more than a graph of emotions. It has meaning in depth, and, at each level, there is a corresponding level of human response to the world. In this way, an artistic form is a symbolic form grasped directly by the senses but reaching beyond them and connecting all the strata of our inner world of sense, feeling, and thought. The intensity of the sensory pattern strengthens the emotional and intellectual pattern; conversely, our intellect illuminates such a sensory pattern, investing it with symbolic power. This essential unity of primary sense experience and intellectual evaluation makes the artistic form unique in human experience and therefore in human culture. Our closest human experience is love, where again sensation, feeling, and idea live in a vital unity.

The essential unity of firsthand sensation and intellectual concept makes artistic vision different from scientific cognition or simple sense-feeling response to situations. It combines both. To repeat, it is the unity of the sensory, emotional, and rational that can make the orderly forms of artistic vision unique contributions to human culture.

It is this unifying power that can overcome the formlessness of our contemporary world. In the task of rebuilding and giving form to our environment, it is imperative to understand the principles of structure. A building stands and serves only if the builder has known how to lay the foundation, if he has respected the materials that he uses and the tools that he works with, and, finally, if an authentic and acknowledged need for the building has governed his intentions. Creative vision is a form-builder par excellence. Painting, sculpture, and other visual art forms are truly artistic images only if they so integrate their material components that the whole structure becomes more than the sum of the parts. Participation in this creative process is an invaluable preparation for building with any material. If we reinforce our powers with this basic experience of forming, we are better prepared to rebuild the physical environment with confidence.

We can build the bridges between man and man if we are willing and able to pool our knowledge and feelings in order to establish a common world of perception based upon twentieth-century standards. Only if we can come to common agreements in our social goals, purposes, methods, and values can our society be welded together again on a new level. Art has an important bearing on this task as well. Creative art form is never an end in itself, it is never completed merely by having been done. Its very meaning is inseparable from the need for expression—thus, for communication. Art, as it is realized in a tangible, visible form, aims to evoke in the beholder the experience of the maker. The artist who intensely experiences a living unit of color, shape, form, is compelled by the very nature of his experience to share this living unity with others. He creates another kind of oneness. The deeper the artist's experience of a form, the stronger his inner need to communicate this form. Inherent in every artist, therefore, is the eagerness to pioneer in developing better tools of communication. The creative response of a painter to a new environment creates new idioms of form and space, and this extends the language of vision. An architect, who in shaping space gives a wider meaning to shelter, enriches the language of space.

Our contemporary art and literature reveal a menacing picture of contemporary man's inner chaos and self-alienation. We are displaced persons, not only historically and socially but within ourselves. Our feelings are intercepted and inhibited by cold reason; the joy in the richness of the sensual world is stifled by sentimentality; our thoughts are muddled by our emotions. Divided, cornered, and discredited within, we are hardly able to mobilize our faculties to cope with problems from without. Cooperation will inevitably fail between men who are not fully human because they are not fully themselves.

Here, too, creative vision can be of great significance. Creative activity is not a superimposed, extraneous task against which the body, heart, or brain protests, but an orchestration of all these in one free act of joyful doing. In an authentic creative participation, all strata of our being move in one direction, in the way a child puts his whole body and soul into whatever he is doing.

Today, for the great majority, work is forced, empty routine, and still worse, leisure, the workless time, is an erosive, passive slavery to shallow entertainments. How can one expect genuine social cohesion when human work is degraded and recreation adulterated? Only in the creative work of the artist, however, do we still have work done with full love for every phase of the activity; the artist follows each step of the metamorphosis of an emerging form with caressing attention. There is hope in Camus' statement:

> "The age of the spinning-wheel is over and the dream of a civilization of artisans is vain. The machine is bad only in the way that it is now employed. Its benefits must be accepted even if its ravages are rejected. The truck, driven day and night, does not humiliate its driver, who knows it inside out and treats it with affection and efficiency. The real and inhuman excess lies in the division of labor. But by dint of this excess, a day comes when a machine capable of a hundred operations, operated by one man, creates one sole object. This man, on a different scale, will have partially rediscovered the power of creation which he possessed in the days of the artisan. The anonymous producer then more nearly approaches the creator." •

We are at the point of no return. Industrialization and urbanization, bringing automation, are with us. Our task is to face the present with the courage of an open eye, an open heart, and an open mind. We cannot renounce the new scientific efforts and technological achievements of the twentieth century because they were bought by human distress. We may suffer from exposure to the new scale, but we have to go forward and meet it. First of all, we have to find the concrete means of dealing with it, both internally through creative, emotional, artistic insights, and externally through constructive measures.

Our central faculty in performing this task, as we have suggested, is visual sensibility. Thus, a key task of our time is the education of vision—the developing of our neglected, atrophic sensibilities. The redirection envisaged in the "Vision and Value" series in general, and in *The Education of Vision* in particular, involves intensifying our creative awareness—seeing more fully. For this we need, first, to systematize our knowledge about the role of vision; second, to find competent methods of developing it; and third, to map the concrete territories where creative vision is to be applied.

The individual contributions in this book come from different disciplines and different backgrounds. They vary in concreteness of expression, and are different in interest and scope. But it is hoped that a synthesis of insights, knowledge, and feelings may be effected, if not in the book itself, then through its stimulation of the reader's mind. The reader will discover recurrent similarities among the various disciplines. As he collates, compares, and evaluates the notions collected here, both for themselves and with regard to their origins in a variety of contexts, a common ground may emerge which will suggest their looked-for interconnection.

•
"Moderation and Excess," from *The Rebel,* New York, Alfred A. Knopf (1954).

This book begins with papers by three psychologists, Rudolf Arnheim, Wolfgang Metzger, and Anton Ehrenzweig, who analyze some fundamental characteristics of our visual faculties. Arnheim investigates the relationship between perception and thought, observing that our preoccupation with intellectual concepts, with words and numbers, has led to the disparagement of sense perception. He points out that our senses are not mere auxiliaries to the intellect; rather, visual thinking is a thinking operation in itself—a powerful and basic means of knowing and reasoning within its own realm. Our fundamental educational premises have to be revised accordingly. Vision can no longer be employed simply to support verbal and conceptual meanings; its potential as a cognitive power in its own right must be exploited. Art education has to be re-evaluated in the broader context of visual thinking.

Metzger investigates the impact of the visual environment upon the formation of visual awareness. Specifically, he studies the relative importance of quality in the pictures upon which children pattern their own visual explorations. Supported by carefully documented evidence, he concludes that children who are constantly exposed to artistic images of a high aesthetic order develop their own visual faculties in a healthier, freer way than those exposed to material lacking artistic quality. Metzger's research supports the age-old notion that aesthetic quality in our visual environment—whether in cities, buildings, objects we use, or pictures—has a definite role in developing our visual creative power.

Ehrenzweig focuses his attention on the interplay between disciplined formal ability and free visual invention arising from the deeper levels of the imagination. Man's creative capacities develop on the conscious level of formal discipline and professional craftsmanship, and on the unconscious level of imaginative thinking that opens up hitherto undreamed-of form-combinations of seeing and feeling. An emphasis on both, in correct proportion, is the only guarantee of that dialogue within one's self which is essential for developing creative awareness on high levels. Those artists who are able to find their inner freedom of imagination and combine it with disciplined control of expression attain the richest, most complete artistic achievements.

The second part of the book explores some concrete aspects of vision as an implement for understanding the physical world. The physicist Gerald Holton surveys the various ways in which visual images could facilitate the comprehension of complex information. Through close communication between artists and scientists, visual analogues that reinforce abstract concepts by powerful, immediate sense images could be developed. What Campanella dreamed about in his Utopian *City of the Sun*—a universal knowledge depicted on central walls in powerful images—is now possible in more realistic dimensions. Improved graphic technique—including the rendering of motion—backed by mass distribution, could make knowledge truly "a public manuscript" if we learn how to read and write vision's contemporary language.

But there cannot be a one-to-one relation between the visualized "reality" of a phenomenon and the phenomenon itself. Holton's important contribution is his penetrating analysis of the specific meanings of "reality" in the presentation of scientific ideas. He emphasizes the point that, when visual means are used to communicate a scientific notion, the images employed necessarily represent a transformation of this notion; they must be used in terms of the clearly defined frame of reference required by the nature of the particular situation. This can involve a didactic reality; it can involve an optical facsimile depicted by film or television; it can involve an analogue in a model or an animation, or any one of a number of other clearly distinct ways of presenting the same phenomenon.

The two essays that follow complement Holton's fundamental discussion by supplying examples. The first is Will Burtin's account of the visual models he designed to reveal, explain, and demonstrate the organization and functioning of structures, organs, and processes in the human body. The result of cooperative work of scientists and designers, these models were designed to introduce at a glance, to the non-professional as well as the professional, relationships that otherwise might take long, tedious study to understand.

William Gordon's discussion of his techniques as an educator underscores the role of images in creative thinking. In class he asks his students to invent metaphors—mentally projected images—that could help them to approach problems from a novel creative angle. This approach has shown impressive results and offers promise of some basically new devices in education.

The third section of this volume deals with concrete techniques for visual education. The first essay here is by Johannes Itten, a pioneer in this field, who recounts the development of his educational ideas in the first part of this century as a teacher, first in Vienna and later at the Bauhaus. There, with the work of Kandinsky, Klee, Albers, and Moholy-Nagy, under the encouraging leadership of Gropius, the first major steps in reorienting the pedagogy of vision were made. Itten's Foundation Course concentrated on freeing the student's expressive visual powers. He broke away from the traditional techniques of art education in an effort to open the eyes of his students to fundamental laws of vision, of importance whatever the professional goal of the student may be.

Maldonado, whose essay follows, is director of the school in Germany that aimed to continue the Bauhaus' work. But, unlike Itten, he geared the educational process to the precise task of designing products for our industrial society. His educational techniques forced students to explore functional factors in design, free from any preconceived formulas or predetermined functions. Maldonado's idea was to assail his students with a wealth of information drawn from our scientific-technical society. By persistently challenging the old solutions to problems and by referring to new, specialized areas of learning, he tried to do away with preconceptions and bring forth fresh approaches to design.

The next two papers deal with the personal philosophies of two leading teachers, one of them a designer, the other a sculptor. Paul Rand, a foremost designer, drawing upon his long experience, emphasizes play as an important source of the creative process. But he recognizes as well that a design task has to abide by the set rules of the game—the limitations imposed on it by the laws of visual organization and by specific tools, materials, and intended function. In design education as in design itself, the balance between the discipline of the "rules of the game" and a free, playful exploitation of imaginative opportunities offers creative solutions. Contrasting with Rand's direct and concrete analysis is Mirko Basaldella's broad, poetic survey. He touches upon the important factors in the formation of artistic impression: historical, cultural, and basic human conditions. He concentrates upon the conflict between the present range of our sensibilities and the immense power of modern scientific knowledge.

The final four papers are concerned with four different aspects of contemporary visual education. Julian Beinart reports on the problems of art education in Africa. Here the confrontation between the values of different cultures is crucial. The artistic achievements of complex, industrial civilizations carry on a vital exchange with the aesthetic values and traditional idioms of surviving tribal artists in Africa. In such an exchange, there is great danger that the values of early cultures will be sacrificed altogether to the advance of the industrial civilization. The challenge consists in attending to their mutual assimilation and so preserving the early artistic values without rejecting the new scientific horizon. Beinart has courageously pioneered in meeting this challenge.

Complementing Beinart's report is Bartlett H. Hayes' analysis of the historical conditions that shaped the attitudes toward art and art education in the most industrially advanced country, the United States. He surveys the evolution of these attitudes from the early part of the nineteenth century to the present, and the consequent modifications of the goals and techniques of art education. In a fundamentally changed world, he suggests, we have to reconsider and redefine these goals, both in educational processes generally and in visual education particularly. Hayes' pioneering in exploring new educational devices and his inventive exhibition techniques lend authority to his observations.

The final two papers present the problems and techniques of visual education in two basically different educational climates in the United States. The experience of Robert Preusser in teaching visual design to students of science and engineering reveals that, by finding the right methods, one can uncover great and unexpected potentials for visual thinking and artistic imagination even in men whose professions have no direct contact with the visual arts.

Robert Jay Wolff comments on problems and methods of visual education within the broad area of general education. He analyzes the opportunities in a "liberal arts" education for an intensification of sensory intelligence and self-awareness. He finds that such an education has broader psychological implications; among other things, for instance, it helps young people to break away from an inbred dependence on authority. His comments imply that a chance to find out by basic experiences the aesthetic orders of form, color, and light, can make the student sensitive to, and capable of dealing with, problems of increasing range and complexity.

All the contributors to this volume agree on two points. First, that there is a fundamental interdependence between perception and conception, between the visual and the rational. The experimental evidence in support of the idea that sensory functions belong to an interdependence system—that there is a primordial unity of sensory and motor processes—is extended to include a corresponding interdependence between the sensory and the intellectual: between art and science. And second, that because the visual factor has been for so long misunderstood and consequently neglected, there is an urgent need today for a re-evaluation of the education of vision.

Peter and Paul are confronted with the same task: "It is now 3:40—what time will it be in half an hour?" Peter proceeds as follows. He remembers that half an hour equals 30 minutes. Therefore 30 must be added to 40. Since the hour has only 60 minutes the remainder of 10 minutes will spill over into the next hour. This gives him the solution—4:10.

For Paul the hour is represented by the circular face of the clock, and half an hour is half of the disk. At 3:40 the minute-hand is placed obliquely at four five-minute units to the left of the vertical (Fig. 1). Using the hand as a base, Paul cuts the disk in half and arrives at two units to the right of the vertical on the other side. This gives him his solution, which he translates into numbers—4:10.

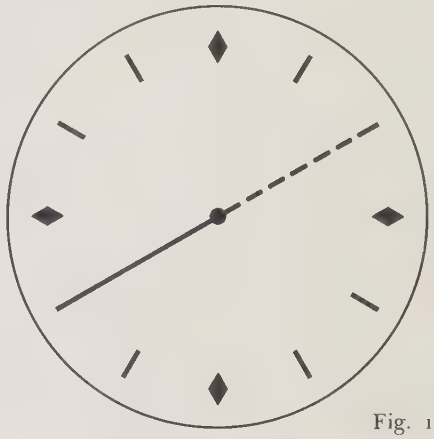


Fig. 1

Both Peter and Paul solved the problem by thinking. Peter translated it into quantities without reference to any sensory experience. He handled the numbers by means of relationships which he had memorized as a child: forty plus thirty is seventy; seventy minus sixty is ten. He thought "intellectually". Paul, on the other hand, approached the problem by a suitable visual image. For him, a whole is a simple, complete shape, a half is half of that shape, and the progression of time is not an increase in arithmetical quantity but a circular journey in space. Paul thought "visually".

Visual thinking is constantly used by everybody. It directs the figures on the chess board and designs global politics on the geographical map. Two dexterous moving-men steering a piano along a winding staircase think visually in an intricate sequence of lifting, shifting, tilting, and turning. A cat thinks visually when it negotiates a precarious arrangement of recesses and ledges by means of a neatly calculated leap. An inventive housewife transforms an uninviting living room into a room for living by judiciously placing lamps and rearranging couches and chairs. Picasso discovers the head of a baboon in a toy automobile. Henry Moore conceived his large upright figure for the Guggenheim Museum as reclining—in the position customarily used by the sculptor—but turned it upright in the midst of the carving process, giving it a strikingly new attitude toward the pull of gravity. Intense visual reasoning occurs every time a sculptor endeavours to unify the various spatial aspects of a work, or when a painter finds the color that will convey the right meaning at the right spot on a canvas.

In all these instances the elements of a problem situation are changed, rearranged, and transformed; the emphasis is shifted, new functions are assigned, new connections are discovered. Such operations, undertaken with a view to attaining solutions, constitute what is known as thinking. And yet, many educators and psychologists are still reluctant to admit that perceptual thought processes are as exacting and inventive and require as much intelligence as the handling of intellectual concepts.

We are the victims of an inveterate tradition according to which thinking takes place remote from perceptual experience. Since the senses are believed to be concerned with individual, concrete events, they are limited to collecting the raw material of experience. It takes "higher" powers of the mind to process the sensory data. In order to learn from experience the mind must extract generalities from the particulars, and in the realm of the generalities no further commerce with direct perception is supposed to be possible. Berkeley, in his *Treatise Concerning the Principles of Human Knowledge,* made this view plausible to generations of readers. For example, the abstract idea of the body of animals refers to "*body* without any particular shape or figure, there being no one shape or figure common to all animals, without covering, either of hair or feathers, or scales, etc., nor yet naked: hair, feathers, scales, and nakedness being the distinguishing properties of particular animals, and for that reason left out of the *abstract idea.*"[1)]

If the operations of thought were assumed not to rely on perception, what vehicle could they use? The unavoidable answer was that man thinks in words alone, and that without words no thinking can take place. What is more, an efficient thinker, whenever possible, employs the most clearly defined sets of words, namely, numbers and other mathematical signs.

Consequently, Western education has been concerned foremost with words and numbers. In our schools, reading, writing and arithmetic are practiced as skills that detach the child from sensory experience, and this estrangement intensifies during the high school and college years as the demands of words and numbers grow and childish things must be put aside. Only in kindergarten and first grade is education based on the cooperation of all the essential powers of the human mind; thereafter this natural and sensible procedure is dismissed as an obstacle to training in the proper kind of abstraction. Some of our most progressive institutions grant the arts respectable academic standing by putting them on an equal footing with the rest of the humanities; but even they do not enlist the capacities of perceptual thinking for the study of the social or the natural sciences. At best, they use "visual aids".

Deprived of their most precious mental powers by a one-sided education, millions of adults will spend their working days exclusively on paper, words, and numbers; they will handle objects they will never see and direct operations by mechanical or remote control.

Perhaps this deprivation of the senses was unavoidable. Perhaps our civilization had to pay this price for the spectacular successes in the sciences made possible by theorizing with disembodied concepts. Owing to this shift of procedures and values the arts came to be considered as means of mere enjoyment or embellishment. Whatever the etiology of the disease, we are faced with a situation in which the arts are still treated as if they were largely recreational and intellectually inferior. All too frequently, art teachers are thought of as persons not clever enough to work in the "better" fields, such as mathematics or history. Dance instruction is tucked away in the physical education department. In the mind of many an influential educator, the manual and bodily skills in all of these areas are still classified with the mechanical arts, as they were in the Middle Ages. There was an ominous ring to the encouragement that came from the president of Radcliffe College a few years ago when "in pointing to the needs for visual art workshops [he] stressed the importance of manual arts to people who are continuously working with their minds."[2)]

The view that the artist is reduced to an activity of primitive and animal-like recording of sensory data, whereas the more advanced type of *homo sapiens* is capable of thought, was expressed with amusing straightforwardness in a speech by I. P. Pavlov, "Concerning the Artistic and Thinking Human Types". Addressing his Wednesday morning seminar at the physiological laboratory of the Russian Academy of Sciences, the eighty-five-year-old father of learning by conditioning said in 1935: "Now, gentlemen, let us turn to the following question. When we analyzed nervous patients in the neurological clinic, I came to the conclusion that there are two specifically human neuroses—hysteria and psychasthenia; I related this conclusion to the fact that man offers two types of higher nervous activity, namely, the artistic type, consequently analogous and close to that of animals, which also perceive the external world in the form of impressions exclusively and directly by means of receptors, and the other, intellectual type, which functions with the help of the second signalling system. Thus, the human brain is composed of the animal brain and of the purely human part relating to speech. It is this second signalling system which is beginning to prevail in man. It can be assumed that under certain unfavorable conditions, when the nervous system is weakened, this phylogenetic division of the brain takes place anew; then probably one individual will use predominantly the first signalling system while the other will use predominantly the second signalling system. And it is this that divides men into artistic natures and purely intellectual abstract natures."[3)]

As though it were not enough for the senses to be considered inferior in their cognitive function, they also acquired a connotation of immorality. By way of the pleasant sensations of gluttony and sex, all enjoyment based on perceptual experience came to be reputed as carnal, witness the ambiguous meaning of words such as "sensuous" or "sensual" (Italian "sensuale," German "sinnlich"). Indulgence in the arts was thought of as sinful, which indeed it is when the function of visual images is restricted to the mere entertainment and distraction of the senses.

The detachment of education from direct experience led to the development of "visual education". Improved textbook illustrations, films, and school television are most helpful in giving content to the words the students are invited to remember and manipulate. But it seems fair to point out that the use of visual material does not automatically produce visual thinking, and this is mainly for two reasons. First, visual thinking entails more than the handling of concepts for which concrete referents exist. "Visual education" is still limited by the old Aristotelian doctrine, which Dante put into verse:

Così parlar conviensi al vostro ingegno;
Perocchè solo da sensato apprende
Ciò, che fa poscia d'intelletto degno.

(This is the proper way to speak to your mind because only from what is perceived by the senses does it learn the things it later makes worthy of the intellect.)[4)] But the senses are not merely the servants of the intellect, that is, its suppliers of raw material. Visual thinking is thinking by means of visual operations. Let me illustrate by a reference to artistic practice. Among the persons who admit that artists think, the notion can be found that thinking, being necessarily non-perceptual, must precede the making of the images, so that, let us say, Rembrandt pondered over the sadness of the human condition intellectually and subsequently put the results of his thinking into his pictures. Granted that painters do not think only when they paint, it must be realized that an artist's most important way of working through the problems of existence is by means of the images he invents, judges, and manipulates. When such an image reaches its final state he perceives in it the outcome of his visual thinking. He knows now what he was struggling to clarify. A work of visual art, in other words, is not an illustration of the thoughts of its maker, but rather the final manifestation of that thinking itself.

The same is true for a student's profit from perceptual material. I remember the shock I received some time ago when I heard a Canadian official remind us that his country bordered on two powerful neighbors, the United States and Russia. As a native of Europe I had always thought of Russia as our neighbor to the East so that by emigrating to the United States I had left that country far behind. To be awakened to the fact that what was far away to the East was rather close by to the North West gave my American re-education a helpful push. This thinking was done by a concrete reorganization of the visual relationships on the map of the world in my mind.

Active handling of visual material, however, is possible only if relevant properties of the objects to be thought about are made evident to the eyes by the images. And here we encounter a second shortcoming of visual education. It is sometimes taken for granted that the mere exposure to images representing the pertinent kind of object will make the student catch the idea, the way one catches a cold. But a photograph may have been taken of a coal mine and yet convey little of what the student is to learn about that subject. We must not put our faith in a primitive, automatically successful magic of visual transfusion.

In a television program for the teaching of physics in the elementary schools I saw a demonstration of how food can be made to boil in a pot by means of solar energy. To see this experiment would have been useful for the children, but the slanted metal planes, which collected the heat rays, were almost entirely unrecognizable because of the dazzling reflections of the sun on the shiny surfaces. Furthermore, the path of the rays, their reflection and conduction, and their actual relation to the saucepan were described in words but not made visible. In other school programs I have seen long shots of factories, landscapes, or city streets, which were little more than vaguely suggestive smudges of gray matter. I have seen objects displayed on distractingly patterned backgrounds, or foreshortened and overlapped in a way that made them undecipherable. Sometimes the logical sequence of a presentation existed only in the spoken comment, and sometimes one set of relations was visible on the screen while quite a different one was demanded by the subject.

On other occasions I have seen excellent programs. Evidently their makers knew that to perceive an object is not simply to swallow its image but to become aware of some of its properties. For example, in order to perceive a gyroscope we must be able to see—not just to infer or to guess—that the object inside the metal ring is wheel-shaped, that the wheel rotates freely around an axle, that the pointed tips of the axle are set into the ring, etc. These properties and relationships must be displayed in the picture by suitable shapes, created by light and shadow, and the shapes must be oriented spatially in such a way as to look undistorted. Overlaps must be made clear by outline and contrast. Figure and ground must be neatly distinguished. In other words, no information about the subject matter will be directly transmitted to the observer unless it is presented in readable shape. Drawings and paintings, which are deliberate translations of objects into visual shapes, do the job of interpretation often more successfully than the approximate and partly accidental shapes of photography.

To see the properties of a thing is to conceive of it as an instance of the application of certain generalities. To see the thing as round is to see roundness in it. That is, all perception consists in the grasping of abstract features. Is this assertion in conflict with that of Berkeley, who maintained that no abstract idea can be perceived? It is and it is not. What Berkeley concluded from his observation was not that abstract ideas are devoid of perceptual content, but that they do not exist at all since they cannot be perceived. "Now if we will annex a meaning to our words," he said, "and speak only of what we can conceive, I believe we shall acknowledge that an idea, which considered in itself is particular, becomes general, by being made to represent or stand for all other particular ideas of the same sort."[51]

We cannot follow the Bishop when he implies that perception is the mechanical absorption of particulars, nor do we limit the term "abstract" to what is devoid of sensory qualities. But all images and pictures do indeed what he says they do: they represent kinds of things by means of individual, concrete specimens. How can this feat be accomplished? Berkeley thought that, for example, a particular triangle can stand for all triangles because we select the properties it has in common with all of them and neglect the rest. However, as far as spontaneous perception is concerned, recent psychological observations seem to confirm the assertion that seeing consists primarily in the grasping of such abstract features as "triangularity", whereas individual differences are acknowledged only secondarily.

We are now ready to suggest that the sense of sight operates through the formation of visual concepts, that is, through shape patterns, which are fitted to the appearance of objects in the environment. These visual concepts have their equivalents in drawing and painting. They show up most clearly at early stages of mental development, when they are still simple. Fig. 2 reproduces two drawings by a six-year-old American girl, who uses the shape of the heart to portray hands, noses, pendants, the top of a strapless gown, etc. The heart is a simple and indeed conventional shape, but the use to

2a

2b

which this child puts it is quite original. She has discovered a shape that suits her own sense of form as well as the appearance of many things in this world. The nature of noses, hands, etc. is understood visually by what the logicians would call their subsumption under the concept of the heart. Such subsumption makes the protean appearances of the environment graspable. They jell, they begin to make sense. To be sure, the simple drawings bear little realistic resemblance to the objects they represent. But rather than dismiss them because of their primitivity we must admire the ingenuity of the young mind in finding basic resemblances among things that, by the standards of a mechanical examination, are so dissimilar.

By applying the same concept to different things the child lays the groundwork for visual categories of a higher order, capable of indicating similarities among objects that have something in common although they differ otherwise. The great network of relations begins to form.

I must refer here once more to the belief—common to philosophers, who are men of words—that concepts can be produced only by means of words. This assumption has led to a triumph of blindness in our own time, but it seems to date back at least to the eighteenth century. Ernst Cassirer, in *Language and Myth*, assures us that "all theoretical cognition takes its departure from a world already preformed by language" because it is the process of naming which transforms the world of sense impression into a world of ideas and meaning.[6] He illustrates this word-struck conception of thinking by a quotation from the essay by J. G. von Herder on the origins of language. Herder describes how primitive man, confronted with a lamb—"white, gentle, woolly"—seeks in the conscious exercise of his mind a characteristic for this animal. Suddenly the lamb bleats, and man "has found the differentia. . . . This bleating, which has made the liveliest impression on his mind, which freed itself from all other properties of sight and touch, stood forth, and entered most deeply into his experience—'Ah! You are the bleating one!'—remains with him. . . ."[7] This theory implies not only that it takes sounds to provoke words; it asserts also that sound alone can activate the power of concept formation and that the only possible vehicle of concepts are words.

What I would like to call the Myth of the Bleating Lamb has by now acquired the status of an uncontestable fact. But to refute the assumption it seems to me sufficient to point to cats, dogs, monkeys and our own speechless infants, who indicate by their behavior that they live in a world of constant entities. Indeed, words are but labels, and there can be no labeling before the senses have furnished defined kinds of things. Hans Jonas has pointed out that "objectivity emerges pre-eminently from sight" because "only the simultaneity of image allows the beholder to compare and interrelate: it not only offers many things at once, but offers them in their mutual proportion. . . ." Also the visual object is detached and distant. It leaves us alone whereas touch and sound exert a direct impact. "The gain is the concept of objectivity, of the thing as it is in itself as distinct from the thing as it affects me, and from this distinction arises the whole idea of *theoria* and theoretical truth."[8]

To deny that our concepts derive from words does not mean to ignore the influence of words upon perception and pictorial representation. In Fig. 3, another six-year-old indicates "the forehead" by a rectangle. This is an unusual delimitation of a portion of a face, which is neither visually nor functionally self-contained as are eyes, mouth, or nose and which is therefore not commonly depicted as an autonomous unit. Quite possibly the verbal notion of the forehead, adopted from the speech of adults, suggested to the child that here was an indispensable piece of facial equipment, which had to be given its due in a visual inventory. However, such an instance is so clearly exceptional that it helps us to understand, by contrast, the very different nature and origin of truly visual concepts.

3

4

Two simple examples of how visual thinking clarifies functional relationships through spatial arrangements are offered in Figs. 4 and 5, drawings in color crayon by a seven-to-eight-year-old. A balloon salesman in his natural habitat is a complex and confusing sight. Pommeled from all sides by his unruly merchandise, he makes his way through crowds, moving his limbs as he bends down to a child, detaches a balloon, takes the money, etc. In Fig. 4, all such accidentals are eliminated. The drawing testifies to the grasping of the essence in terms of visual space. The principal figure is placed in the center on an empty, undisturbing ground. The equal role of all the balloons is expressed in their symmetrical grouping around the hands of the salesman. Logically speaking, the balloons are homotypic— "they have the same logical place, role, and function in the whole".[9] A system of radii connects them with the holding, controlling hand. None of all this has been perceived in the mechanical sense of the word. Rather did the child arrive at visual understanding through the active inspection and organization of the salient factors, which he extracted from a confusing setting. Similarly, in Fig. 5, a social situation is defined by a clarification of its visual image. The restless child, as the chief character, holds the center of the picture as well as that of the dinner table and is properly framed by the chair and illuminated by the candles. The two parents are homotypic and therefore placed symmetrically. Seated on the sidelines and smaller in size, they bespeak their subservient position in the group, like two saints flanking the Virgin in an altar painting. And the essential difference in initiative is conveyed by the jauntily raised arms of the daughter in contrast to the dejected passivity of the grownups.

5

Many processes of thought, familiar from intellectual reasoning, are no monopoly of the intellect. They occur in visual thinking as well. In fact, they are likely to originate in the perceptual realm and be translated into intellectual operations later. As an example I will choose the development of the concept of interaction. Among the fundamental notions every human being must acquire is that of how physical or mental entities modify each other. At the simplest level of thought, objects or persons are conceived of as self-contained, isolated, immutable, and closed. In the earliest drawings of children individual items float in space, unanchored and unrelated. At a later stage they keep each other company in a common spatial setting, as for instance in the family portrait (Fig. 6) done by a three-and-a-half-year-old Japanese boy. He portrays himself between his father and his mother. There is coexistence, but apparently no interaction. After learning to represent the profile-view, an older child will be able to show intercourse among isolated figures.

6

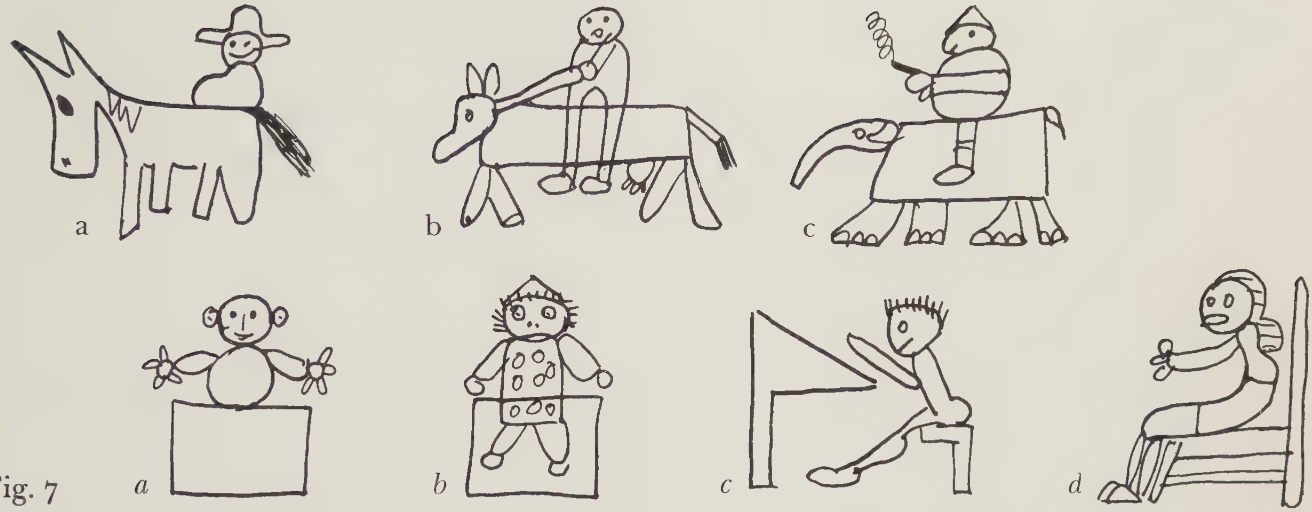


Fig. 7

The true problem of interaction, however, arises only when entities engage each other physically in such a way as to modify each other's visual appearance. An illuminating example is the problem of how to depict horseback riding. In Fig. 7 I have schematically illustrated various stages of the solution of this problem. Two entities, man and horse, get involved with each other; but what exactly does such interaction do to them? At the most elementary level of thought, interaction is conceived of as mere contiguity: man and horse border upon each other (a). They touch each other, but their integrity is unimpaired. A second stage (b) goes beyond mere neighborliness: the two entities cross each other, but although they overlap in space they do not yet acknowledge the partner's presence by any modification of their own shape. They look as they would if they were alone. Later, however, (c) the rider loses one of his legs; that is, the child has recognized that things change each other when they meet. Mutual influence leads to modification, and integrity must make concessions. I need not spell out here the fundamental importance of this piece of insight. Parallel developments of thought occur in the natural sciences as well as in social relations.

An additional aspect of the same process may be studied in the gradual mastery of the problem of how a human body is seated on a chair (Fig. 7). This is a difficult task even physically as everybody knows who has watched a young child trying to negotiate a chair. Here again the earliest stage of the drawings presents the relationship between person and chair as mere contiguity (*a*), and at the next level the human figure simply crosses the chair, unimpaired and unimpressed (*b*). At the more mature level the child has learned that an internal modification is necessary for objects to adapt to one another. The child recognizes the mobility of the joints (*c*), that is, he conceives of alterable relations among the parts of a composite; or he bends the oblong of the body (*d*), indicating that the shape (nature, character) of a given unit is no longer considered as immutable but can change in response to the demands of the context.

Here again we are dealing with a universal feature of the development of thought, as may be illustrated by a reference to language. In languages of a relatively simple grammatical structure, such as English or Chinese, the sentence consists of unalterable word-units, whose function in the whole and relation to their neighbors are expressed only or mainly by combination and sequence. In structurally more complex languages, such as Latin or German, the role of the word in the context is expressed by a modification of the word itself. In fact, the terms "inflexion" and "declension" derive etymologically from "bending", thus revealing their perceptual origin.[10)]

What I have shown for the concept of interaction can be made evident for other thought operations as well. Thinking originates in the perceptual sphere, and we are beginning to suspect that much of the truly creative exertion of the mind in any field and at any level consists in perceptual operations! In a well-known letter to Jacques Hadamard, Albert Einstein said: "The words or the language as they are written or spoken do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be 'voluntarily' reproduced and combined." And further: "The above mentioned elements are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in a secondary stage, when the mentioned associative play is sufficiently established and can be reproduced at will."[11)] If Einstein's procedure is representative of intelligent reasoning we may be strangling the potential of our brainpower systematically by forcing our youth to think primarily with verbal and numerical signs.

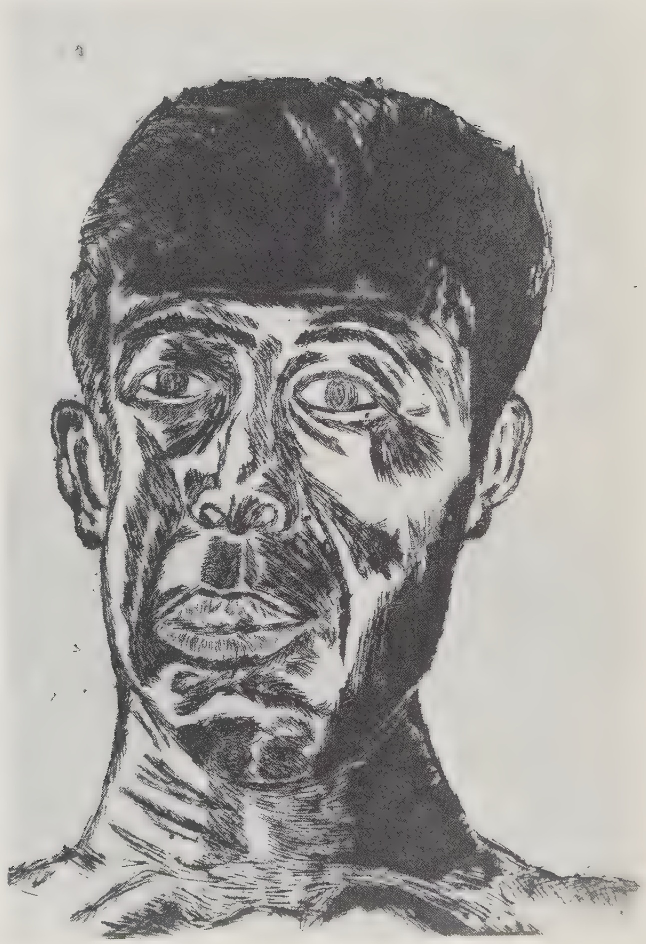
It will be evident that I am not merely talking about "art education". Art, as the most conspicuous island of creative vision, is given an excessive importance in our civilization. What happens in the art room, in the studio, and in art galleries and museums matters and accomplishes relatively little as long as art dwells as a stranger in a social setting suffering from sensory illiteracy. Art can make sense only as the supreme manifestation of a culture pervaded throughout by creative visual thought.

However, since the fine arts are the epitome of visual thinking, art education must serve to demonstrate this power of the mind most purely. To what extent does it succeed in this task? What I have said and shown indicates that visual thinking aims at clarity obtained by significant order. In the course of such a thought process, a confusing and incoherent situation of uncertain relations is restructured, organized, simplified until the mind is rewarded for its labor by an image that makes meaning visible. To accomplish this task, the image must meet two requirements: all of its elements must fit into an integrated whole, and the whole thus created must embody the intended meaning. I can no more than hint at some of the factors that stand in the way of such accomplishment.

The mechanical imitation of models precludes the organization of form. In our day the daring shapes and colors of modern art have replaced the plaster casts of the past, but copying obstructs visual thinking whatever the model. Figs. 8 and 9, both representing a "face", were done by Japanese schoolboys, 13 and 14 years old respectively. Fig. 8 is clearly not an account of a human face by means of pictorial form but an aimless play with elements of modern painting. The choice and combination of shapes—and of colors as well—are almost entirely arbitrary, and the result is chaos. Fig. 9, surely not a first-rate piece of work either, is clearly inspired by its subject, the human face. An attempt is made to understand the interplay of the volumes that carry the expression of the whole. The physical unity of the model has impressed some measure of perceptual unity upon the drawing.

The point of the demonstration is not that the first picture is more "modern" than the other, but that it is not directed by the object it purports to represent—as, for instance, most of Picasso's "faces" are, regardless of how much they deviate from the model—and that the relations between the shapes are so accidental and piecemeal that the eye cannot read them.


8

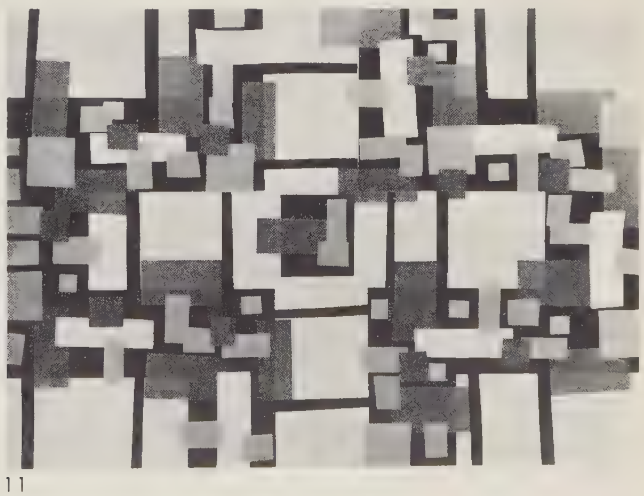

9

An equally serious disorientation of basic purpose distinguishes Fig. 10 from Fig. 11. Both were done by Japanese sixth-graders, the former in the public school of a small town on Okinawa, the latter in Tokyo. Fig. 10, rewarded with a grade A by the proud art teacher, results from the willful disintegration of elements derived from the figures of a fairy tale. The reproduction in black and white gives only an inkling of the frightening confusion created by a helpless but probably amused child at the instigation of a well-meaning instructor, who has not been told by his Western or Western-oriented professors that demolition derives its value from reconstruction, that freedom without order is sterile, and that the energy released by spontaneity must be gainfully employed.

Fig. 11, on the other hand, shows remarkably sure and subtle control of a complex theme. This is the achievement of a youngster who has been taught, by implication, that intricacy is a challenge to the sense of order. Will he be immune against the suggestions of those who will tell him that, in art or elsewhere in life, the proper reaction to chaos is to add to it some chaos of one's own? Or may we hope that the exhilarating experience of clarification, which came to him through the devoted discipline of his eyes and hands, will help to further in him the courage of the explorer, the sympathy of the helper, the imagination of the inventor, and the rationality of the builder?

1. George Berkeley, *A Treatise Concerning the Principles of Human Knowledge,* Introduction, IX.
2. *Harvard Crimson* (February 6, 1957).
3. I. P. Pavlov, *Experimental Psychology and Other Essays,* New York (1957), p. 589 ff.
4. *Paradiso* IV, 40–42.
5. Berkeley, *op. cit.,* Introduction, XII.
6. Ernst Cassirer, *Language and Myth,* New York (1946), Chapter 3, p. 28.
7. Johann Gottfried von Herder, *Ueber den Ursprung der Sprache,* Berlin (1770), Part I, section 2.
8. Hans Jonas, "The Nobility of Sight, a Study in the Phenomenology of the Senses," in *Philosophy and Phenomenological Research* (1954), Vol. 14, pp. 507–519. Compare also the same author's "Homo Pictor und die Differentia des Menschen", in *Zeitschrift für Philosophische Forschung,* Meisenheim (1961), Vol. 15, pp. 161–176.
9. Max Wertheimer, *Productive Thinking,* New York (1959), p. 93.
10. Compare the German grammatical terms "Biegung" and "Beugung".
11. Jacques Hadamard, *The Psychology of Invention in the Mathematical Field,* Princeton (1945), appendix II.

10



11

WOLFGANG METZGER

THE INFLUENCE OF AESTHETIC EXAMPLES

The reflections and observations contained in this paper are not based on discussion in the psychology laboratory, but rather on the actual practice of educating children. The problem under consideration is the development of artistic taste in early and late childhood. The specific question is whether it really makes any difference what kind of music, art and literature we offer our children. The two factions which usually oppose each other during any discussion of this question are well known and both support their viewpoint with impressive arguments.

One faction is of the opinion that it is unnecessary to be particular in the selection of illustrated books, texts and wall decoration. It holds that children should be given what they desire, and that what they dislike should not be forced on them. Even when children, as our experience shows, prefer or even love a text or an illustration which in the opinion of grownups is perfectly worthless, one can assume that their taste will correct itself with time. The advocates of this opinion can point to quite a number of experiences of this kind; indeed, almost every one of us can probably remember the sugary angels and sentimental greeting cards which we admired during our childhood, or favorite pictures about which we can now only smile or shake our heads.

However, there are also experiences of another kind. In Münster we experimented with psychology students between the ages of twenty and twenty-five, asking them to arrange a number of portrait reproductions according to their excellence. The students were asked to be wholly unselfconscious and judge simply according to their feelings. Occasionally it happened that a student would pick some unquestionably worthless devotional picture and prefer it to a Holbein, a Cézanne, or a Van Gogh, in spite of the fact that a certain sensitivity to art was evident in the rest of the student's arrangement. During the subsequent interview the student would tell us, for instance, that this particular painting had hung above his bed when he was a child and that he had come to love this painting so much then that even now he preferred it to any other.

Hans Friedrich Geist, a German art teacher, once said: "With regard to paintings, children are like hungry fish. They grab up everything that swims toward them and cram it into their eyes. What don't they love, swallow and gobble up simultaneously—digestible and indigestible material, genuine and fake, the valuable and the synthetic." It has not been proven statistically, but this probably does hold true in the case of children whose artistic norms are not yet very demanding. Where it has been possible to create and sustain definite norms and expectations it certainly is not the case, but no statistics to prove this point are available either. All I can do is point to the following single experience which does not even have to do with painting, but with music.

The parents of a group of four children between the ages of five and fifteen had practiced with them, for more than a year, only hymns in the seventeenth and eighteenth century versions, which the children enjoyed very much. One day these same children were asked to sing the somewhat innocuous German children's songs of the nineteenth century. These songs were the usual fare in the German middle-class household and kindergarten, and these same children remembered having enjoyed singing them earlier in their lives. But now none of these children, including the youngest, wished to sing these songs: "silly stuff" was their comment. Here the norm had been considerably altered and raised simply through exposure without direct instruction.

How then do norms come into existence? This has been the subject of numerous psychological inquiries which are usually not cited in this connection because they apparently have little to do with questions of aesthetics and taste. But the results of these inquiries clarify an important part of the problem, even though they do not yet take into account certain—perhaps essential—socio-psychological points of view. I am referring to the "central tendency of the (absolute) judgment", probably first determined by Hollingworth in 1910. His investigations are based on Müller's and Schumann's work of 1889 on the intuitive "absoluteness" of characteristics. We will here try briefly to explain this.

If one compares the lengths of lines in pairs in order to determine difference thresholds and if one takes a series of lines which varies from length A to length C as a means of comparison, the observer will notice after a while, with some astonishment, that a single line, which exists without anything to compare it with, gives the impression of being either "large" or "small", "long" or "short", all by itself. For example, all lines longer than median length B appear large or very large; all lines smaller than B appear small or very small. But as Hollingworth was able to discover, the impression of largeness or smallness is only seemingly absolute. If one enlarges the series, adding either larger or smaller lines, the demarcation between the seemingly small and the seemingly large lines is slightly displaced. In the first case, the lines which previously appeared large now seem small; in the second, the lines which first appeared small now seem large. If the series, which at the beginning of the experiment varied between A and C, now encompasses B to D, the lines whose size falls between B and C—originally the larger ones—now become slowly but surely smaller. Size B, which at first was neither large nor small—which was the normal size—has now become the largest, and size C, which at first was the largest, is now the normal size.

What has been demonstrated here with the multiplicity of the lengths of simple straight lines can be applied to the variable characteristic of any object, and as such also to the rank of a work of art or to any created form. Thus one can say in general that the median value of any given field of variation becomes—from some point of view—the norm, and this obviously happens without any doing on our part. But this does not imply that anything at all has been said about the meaning of the frequency with which any of the single variants appear.

We can therefore predict with some certainty that a child who has been exposed to inferior, unformed, and unauthentic pictorial material for many years will inevitably perceive the inferior as normal, even if a kind of revolution, a dethroning of the false gods, an enlightenment about the true norms of the beautiful, can occur later on. On the other hand, if we want to nurture a more exacting norm in the child from the beginning, we must offer him only exacting visual nourishment and he should be exposed to superior examples to such an extent that he will be completely filled with them, for unavoidably in his daily life he will constantly meet with the inferior.

One question which remains open is how such categories as those described as "completely out of the question" and "unspeakably bad" are formed. The question of the formation of such categories and of their demarcation is important because only through the establishment of such demarcation can the mass of inferior material to which every human being is inevitably exposed—at least in the industrialized countries—be prevented from lowering the norm, as Hollingworth's continuous distribution would lead us to expect. Investigations of the spontaneous formation of such categories are under way, for instance with Witte in Tübingen. But in my judgment, no indisputable inferences about the stability of norms of taste can yet be drawn from these investigations. It does seem very probable, however, that the first norms of taste are formed according to Hollingworth's "central tendency", and that on the basis of the average fare which our children receive, a demanding taste cannot develop spontaneously. Rather, planned guidance by adults is necessary.

The discovery that children's norms of taste are influenced by the works of art which they find in their surroundings and with which they play was recently tested in Münster in order to get a better grasp of this subject. The experiments made were somewhat stringently formulated, in order that one might have objective material to work with instead of opinions.

It was asked whether examples to which children had been exposed for not too short a time had had a measurable effect on their own work, and whether this influence was significantly different with different kinds of examples. Irmgard Schwarz investigated children's drawings; Sister Hildegonda Rosenbaum, the written narration of adolescents. To the extent the subject matter would allow, the investigations were held in the same manner.

The drawing experiment was performed with seventy-five children: five mixed groups of fifteen children each. Their average age varied between five years and seven months and six years and one month. None of them had yet attended school. The investigations took place in five different kindergartens in the Rhineland. These were carefully chosen from a list of four hundred kindergartens so that the general atmosphere would be as much the same as possible. All of these kindergartens were located in the suburbs of cities of the Rhine-Westphalian industrial area. The children came mainly from a middle-class background. The kindergarten teachers all possessed a special understanding of what is involved in developing the artistic tastes of young children.

The written narrative was investigated in three classes of a girls' school which taught mainly home economics. The school was located in a small Westphalian town and was run by nuns. The number of children in each class was sixteen, eighteen, and nineteen respectively, i.e. fifty-three altogether. They were all between the ages of fourteen and seventeen.

In both cases the entire experiment consisted of three phases:

1. The original assignment;
2. Period of being influenced:
   four weeks for the children,
   five for the adolescents;
3. Repetition of the assignment.

The pictorial assignment was to draw with a pencil a man, a tree, and a basket with fruit in it. Because of the age of the children the assignment was formulated in these words: "We are painting a father who is in a garden; he picks apples and puts them in a basket." There was no time limit given for the assignment.

The linguistic assignment was to recount what happened in a film made up of silhouettes, having neither sound nor subtitles. The film, which was shown twice in a row so as to make sure that the children had been able to follow all of it, told the story of "The Golden Goose", a lighthearted fairy tale by the Grimm brothers. The experiments were performed during the German lesson. We had to make sure that the girls would not be overly concerned with their orthography and therefore they were given the following instructions: "Recount the fairy tale in writing just the way you saw it. Imagine what the individual persons might have said. Don't worry about spelling and punctuation. What is important is that you tell everything well." There was no time limit for the assignment.

The different groups in each experiment were exposed to the influence of different examples. All the examples used in the drawing experiment were simple, line drawings of the three subjects mentioned above: basket, tree, man. The examples for each group were the following:

Group 1:
Reproductions in line of motifs from Egyptian sarcophagi of the Eighteenth Dynasty. (Fig. 1)

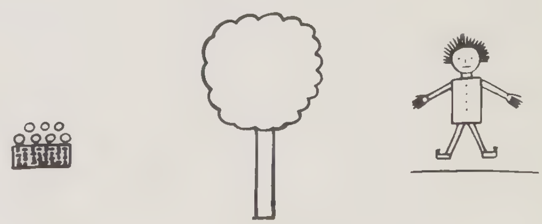
1

Group 2:
Drawings by a modern graphic artist, Alfred Zacharias, well known in Germany. (Fig. 2)

2

Group 3:
Drawings from an ordinary coloring book, without the least artistic merit. (Fig. 3)

3



Group 4:
Drawings by ten-year-olds, i.e. by children whose capacities had undergone considerably higher development. (Fig. 4)

4

Group 5: A control group used as a means of comparison; it was shown no examples during the period between the two assignments.

During the twenty-four school days that they were being influenced, no other pictorial influences were available in the kindergartens. The wall decorations were removed immediately after the first assignment and the coloring books were locked up. The wall decorations were replaced with the respective examples of the basket, tree, and man, in that order, and right next to each other. The children were given no explanation for the replacements, nor was any pointed reference made to the examples at any time. During the following four weeks the children were conscientiously observed and their behavior and expression, especially with regard to the examples, was duly recorded. The children had plenty of opportunity to draw on their own during the play periods; paper and crayons were always at hand. The children took full advantage of the opportunity to draw and we have a number of drawings from this intermediate period indicating the various stages of the development that took place. The examples were not visible when the assignment was repeated after four weeks.

There were not as many possibilities for examining the narrative style of the fourteen- to seventeen-year-old girls, and therefore there were only three groups: two differently influenced main groups B1 and B2, and a control group A which was not influenced. In German there exists material which is highly suitable for this kind of comparative test, i.e. two different versions of the same fairy tales, both of which contain identical fables, have mostly the same titles, and are equally well known and well liked: one is by the Grimm brothers, first published in 1812, the other collection is by Ludwig Bechstein, published in 1845.

The Grimm fairy tales belong to the classic documents of German prose. The quality of their language approaches Luther's translation of the Bible: serious, straightforward, calm, concise, figurative, lacking superfluous ornamentation and rhythmically compelling.

The language of Bechstein's fairy tales, on the other hand, is mannered, often somewhat abstract, often affecting wittiness, then again obtrusively moralizing, overemphasizing the negligible while often neglecting the essential.

There were fifteen hours of German instruction during the five weeks. During each hour one fairy tale by the Grimm brothers or by Bechstein was read by the teacher to the respective groups. They were informed that it was an exercise to teach them how to tell stories at home. Once the fairy tale had been read it was discussed by the class and in the following German lesson one of the students would be asked to tell the story in her own words. This retelling was not criticized at all. The tale of "The Golden Goose" was not among the stories read to the students during the period between assignments. The silent film of this tale was shown to the girls once more at the end of the intermediate period, just before the repeat assignment.

The choice of two such different age groups was not an accident. For various reasons the six-year-olds were particularly suited for the drawing test. The will to create is still completely sound and unharmed at that age. Also, several characteristic developments are taking place at this time of life—especially in the representation of human beings. The child is discovering the possibility of representing in profile; the individual features of the single figure are becoming more numerous; the different parts of the body are being represented more completely: simple line renderings of arms and legs, for instance, are replaced by more plastic representations. Proportions are being observed more closely; directions begin to be differentiated from one another, i.e. the children become capable of scaling down areas, of attaching limbs at odd angles, of bending them, of making them asymmetrical with one another, and of having entire figures diverge from the vertical. They are beginning to take into account the force of gravity, as is noticeable in the way the fruit is stacked in the basket in the children's drawings. Furthermore, the children are discovering how objects look when they intersect and overlap. And finally, they are also discovering that one can show how the individually drawn objects function and act in relation to one another.

Our investigation concerned itself solely with the question of whether this development of the artistic capacities was influenced or possibly hastened by one or the other of the examples. A scoring scheme, developed by Heckhausen and Holstein in Münster, was available for the evaluation of the human figure. For the evaluation of the tree this scheme was correspondingly modified. For the basket of fruit a new though essentially similar scheme had to be developed. This scoring scheme made it possible to ascertain the level of graphic development quantitatively by counting the individual features with which each figure was endowed.

The creative formal ability, i.e. the strength and fullness of delineation of the artistic expression—something quite distinct from the level of development—was not taken into account, because we could not measure it quantitatively in an analogous manner.

From the age group selected for the investigation into linguistic development—fourteen- to seventeen-year-old girls—one can expect a certain command over the written word. Indeed this is the only form in which this experiment could be held. This age group too is undergoing a comparatively rapid and characteristic development, in this case of its linguistic capacity. The particular development here has to do with the characteristic trend toward introversion in adolescence. By this we mean a growing interest in the particularity of different persons (also the different persons in a story) and the growing receptiveness to changing moods, feelings, thoughts, conceptions, and motives of the other person.

In the case of the linguistic experiment no absolute scale of values existed for the evaluation of the documents; therefore we were forced to dispense with such an absolute scale. The analysis of the stage of linguistic development turned out to be fruitless. From the written assignments of the students, however, we were able to pick out a number of very noticeable stylistic features, i.e. signs of strength and richness of delineation in the use of language. In contrast to our evaluation of the drawings, here we did pay particular attention to signs of formal ability. To begin with we noted ten stylistic differences between the Bechstein and Grimm groups, which, in spite of the fact that some of them overlapped, proved to be sufficiently useful. For example: indirect address vs. direct address; direct naming of character qualities vs. suggestion of qualities through behavior and action; description of objects vs. description of action; affected expression vs. simple expression; general designation vs. specific designation; ascertaining the amount of space devoted to a particular event with regard to its importance to the whole, etc. All obvious improvements or deteriorations in the documents of the students were picked out with the help of these categories. The difference between deterioration and improvement is the net improvement; it can be either negative or positive.

What are the results of these two parallel investigations? In both experiments the children were influenced in a specific manner by the examples. In both cases the groups working with the outstanding examples showed considerable improvement, while the harmful effect of the inferior examples was less marked in comparison with the control groups which had not been shown any examples. It should be kept in mind that the control groups also underwent some change during this period, for which there are undoubtedly several reasons: the closer acquaintance with the situation and the particular assignment in itself is not an insignificant factor.

In the drawing experiment the average improvement of the control group was +1.5 units, while the greatest improvement, that of group 1, was +35 units and the least improvement, group 3, was —18 units.

The average improvement in the control group of the linguistic experiment amounted to +4.3 points, while the corresponding number for the best case, that of group B1, was +36 points and for the worst, group B2, —10 points.

In order to eliminate the displacement of the control groups we assign these groups +1 progress points and all other changes are from now on related to this number.

The relative improvement for the other groups of the drawing experiment averages out as follows: group 1 (Egyptian sarcophagus motifs) 9.8; group 2 (modern graphic art) 4.9; group 3 (coloring book) 0.5; group 4 (children's drawings) 0.2.

The group which was under the influence of the artistically valuable examples improved, as one can see, almost five to ten times as much as the control group, while the group with the examples of questionable value improved only half or one fifth as much. The upward deviation of groups 1 and 2 is very significant; the downward deviation of groups 3 and 4 is not, even though it accords with our expectation. The great improvement in group 1 and group 2 holds true not only in exceptional cases but was general throughout these groups. None of the children in these two groups gave any sign of decline. Two children remained on the same level; all other thirteen children participated to one degree or another in the improvement. In the other groups, as well as in the control group, six children improved, five remained on the same level, and four declined.

The relationships are very similar in the results of the linguistic experiment. If we posit the improvement from the first to the second assignment in group A, the control group, to be +1 point, then the average net improvement in the group under the influence of the stylistically excellent example (Grimm) is +4.24 points, while in the group with the inferior example (Bechstein) it is only +0.59 points; in other words, group B2 remains far behind the spontaneous improvement of the uninfluenced control group.

In group B1 all nineteen girls show a net improvement of at least +5 points, at best +36 points; seventeen of these girls improved by more than +10 points.

Of the sixteen girls in group A, the control group, twelve show a net improvement of 2 to 16 points, surpassing +10 only three times. There is a net decline of —1 to —6 points in four instances.

Of the seventeen girls in group B2 only ten improved, their improvement varying from +2 to +15 points and only in two instances higher than +10 points; three girls remained on the same level and four declined by from —1 to —10 points.

With these hints we close our discussion of the linguistic experiment. But now we do want to delve somewhat more deeply into the results of the drawing experiment.

We discovered that the level of graphic development was heightened to a very different degree with the use of different examples, in some cases more, in others less, than in the control group. What do these differences mean? Let us first of all look at the situation with the "good" examples, and ask how it happened that the improvement under the influence of the Egyptian example was almost twice as great as that with the modern one. A whole series of factors whose effects one might take into consideration—the age, the basic performance, and the sex of the children—proved to be unimportant. The level of the examples themselves was also examined; they were evaluated with the same scheme that was used to evaluate the drawings made by the children tested. The score of the Egyptian example was lower than that of the modern one. Thus the level of development of the examples proved not to be the decisive factor. Rather, decisive for the better results obtained with the Egyptian example was apparently the fullness of delineation of artistic expression which, as we know from art history, is different at each possible level of artistic development; it can also be very high at a low level. It was this which fascinated the children and compelled them to involve themselves more deeply with the Egyptian example.

This seems to prove, contrary to what we had assumed in the beginning, that children after all do possess a native sense for differences in artistic value, a sense which, if this is true, is only atrophied later on in life through overexposure to inferior material. This speculation seems to be borne out by the reaction of the girls during the reading of the fairy tales. Most of these stories were already well known to the girls and they were therefore bored at first. But during the reading of the fairy tales by the Grimm brothers they quickly became fascinated and listened carefully and were sorry when the reading was over. Bechstein, on the other hand, did not hold their attention and it was difficult for them to suppress the resulting restlessness.

Let us now return to our visual experiment and examine in some detail the relative richness or fullness of portrayal of the expression in example 1 and example 2. Compare in each how the trunk and the branches are differentiated, how the branches are shown to grow out of the trunk, how the branches bend, break off or intertwine. Compare how the leaves are arranged and attached to the branch. Note, for instance, that in example 2 some of the leaves are not attached at all but are distributed mosaic-like across the area. Similar details could be compared in the human figures of the two examples. Note in example 2 the tong-shaped hands, the square pocket, etc., which would seem to lend themselves to schematic copying.

The drawings made by the children for the repetition assignment show that a greater fullness of delineation or richness in the artistic expression of the examples does not influence the children to copy particular individual features schematically. Rather it stimulates the child to achieve a higher degree of structural realization within his own sphere of formal creativity; i.e. a genuine intellectual development takes place. Fig. 5 is an example of this development seen in three stages of the representation of a tree by a child in group 1. Tree (a), drawn for the first assignment, shows the branches radiating from the trunk of the tree. Tree (b), a representation executed during the intermediate period while exposed to the influence of the Egyptian example, shows the branches arranged along the sides of the trunk. Finally, tree (c) shows a reversion to the original manner, but on a higher level of development. In other cases in group 1, the drawings for the repetition assignment even surpass the example

Fig. 5.
Three stages in the representation of a tree by a child in Group 1.
a: Before exposure to Egyptian example.
b: While directly exposed to Egyptian example.
c: After exposure to Egyptian example.

in the degree of structural organization. For instance, the feet of the man are drawn with individual toes and the suggestion of the ankle bone, none of which can be seen in the model.

To this favorable development achieved under the influence of the Egyptian example one can compare the by no means auspicious effect of the tong-shaped hands of example 2 upon the children of this group (Fig. 6).

It is not particularly surprising that example 3 (ordinary coloring book) did not have a good effect. The paradigms shown were so coarse and primitive that even the six-year-olds disliked and made fun of them. The results from group 3 unfortunately have to be evaluated with certain reservations. As we discovered only later on, the entire group had an excellent home life and was under constant supervision by their mothers. This became evident when the first drawings of this group showed a level of achievement not reached by the other groups until the second assignment, if then. Whether this group would have improved had it been given better examples is doubtful. This part of the experiment should be repeated under more controlled conditions. But the decisiveness of our general conclusions remains unaffected.

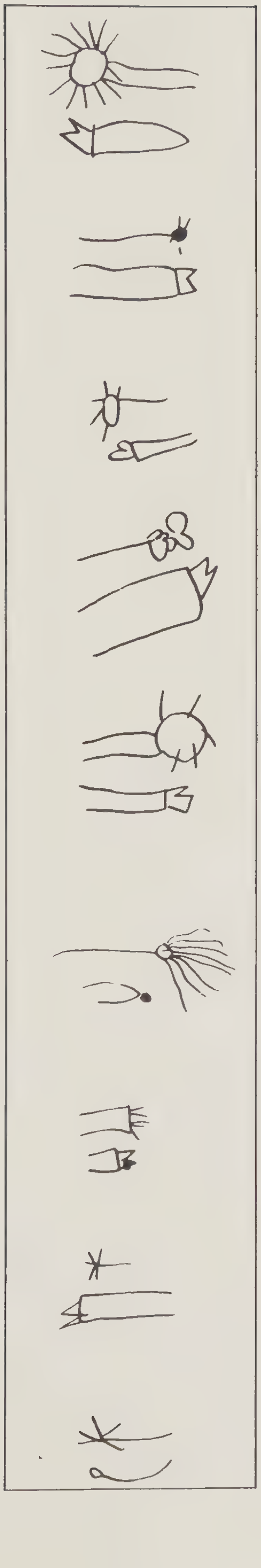


Fig. 6.
Nine cases demonstrating the negative influence of the tong-shaped hands of the example used in Group 2. In each case the upper drawing is a representation of a hand before exposure to the example and the lower is a representation of a hand by the same child after exposure to the example.

More surprising are the results of group 4, which was under the influence of the drawings of older children. The examples were on a considerably higher level than anything our average six-year-old could produce. The tree, to be sure, is stiff and unorganic, and the manner in which the leaves are attached is absolutely unnatural, but at the same time the tree is constructed more distinctly than the one in example 2. The man is not too well proportioned but much less schematic than in example 2. If the children of group 4 had observed their examples more closely they could have learned something from them. Yet the rate of improvement is the lowest in this group, even lower than in the group which had been influenced by the coloring book. One could almost say that these children's drawings had exerted an even less favorable influence. But this is not the case, as we gather from a number of symptoms, one of which we will cite here. In the drawings executed by all groups for the first assignment, the man was shown from the front in almost every case. In the drawings for the repetition assignment, profile representations were more numerous. This change is especially marked in group 2. Now, the human figure in example 4 is as clearly delineated a profile as the one in example 2, but the increase in profile representations was much smaller in group 4.

This and a number of other symptoms, as well as the records kept by the kindergarten supervisors, indicate that the children simply did not pay any attention to the children's drawings. They did not take a close enough look to notice that anything could be learned from them. This means that children hold children's drawing in as little esteem as do adults. In their opinion the drawings are incomplete, will be quickly surpassed, can be practically done by themselves, and therefore do not merit admiration or even attention. The children of group 4 behaved exactly as Geist expected them to: "The child demands that the pictorial world which we offer him be different from his own. He longs for experiences and insights which he himself has not had; he wants to gain something which points beyond his own situation. And that is why the child is justified in rejecting drawings or paintings done in a 'children's style'."

We have come to the end of our observations and are now able to say that the healthy child is endowed with a basic feeling for artistic merit—both in the visual and the linguistic field. This is something we had not expected. But this predisposition is apparently so fragile that responsibility for the growth of artistic norms does rest with the environment.

It was demonstrated how the ability to write and to draw can be affected to a surprisingly high degree—both favorably and unfavorably—by the examples to which a child is exposed. And there can be no doubt that even under conditions less extreme than those which prevailed in our experiment, wall decorations, texts, comic books, etc. exert a corresponding effect on the child, especially because the child is under their influence for such an extended period of time. Now that this is known, the influences can be controlled.

Quite a number of questions still remain unanswered, and our results are not yet final. They need to be supplemented and verified once more through further investigations. But even now we have in our possession a conclusive argument against all those pedagogues who consider superfluous, or even oppose, a controlled influence or appreciation of style in the visual and linguistic arts. Likewise we can now counter all those who for some reason do not believe that it is necessary to be very discriminating in the choice of texts, illustrations, and room decorations for children, and who allow business and industry to dictate the shape of the world in which their children grow.

ANTON EHRENZWEIG

CONSCIOUS PLANNING AND UNCONSCIOUS SCANNING

Professional skill in art and science often inhibits the full development of the creative imagination. Conversely, methods of art teaching that primarily aim at stimulating the student's imagination rather than at imparting craftsmanship (as frequently in the teaching of children) may succeed in producing imaginative and powerful work, but the work will lack professional finish and a clear-cut purpose.

Professionalism and imagination ought not to be antagonistic in this way. That they so often are is due, in my view, to a wrongheaded conception of craftsmanship and professionalism. The very word "craftsmanship" has acquired a moralistic ring that is missing in equivalent expressions in other languages. One of the supposed duties of a good craftsman is to bring the entire working process under conscious, fully deliberate control. He must visualize clearly the outcome of his work and plan the most direct route for achieving this visualized result. Unplanned accidents, however happy in their effect, would still indicate a lapse of proper control.

It is, however, this straining after a fully deliberate technique that tends to exclude deeper levels of the personality and so inhibits the free play of imagination. This danger is now generally appreciated. The last decade or so has seen an efflorescence of courses in basic design in which the student is encouraged to experiment more freely with the various artistic media without any definite practical purpose in mind. But the antagonism between professionalism and imaginativeness is not resolved. The new freedom of imagination is usually lost as soon as the student has to accept a modicum of planning and control. These recurrent failures have cast doubt on the lasting value of basic-design training. Nevertheless current reforms in British art education still try to inject a broader training of aesthetic sensibilities into professional courses for artists and designers. I feel that these and similar attempts at reform will be hamstrung if they do not try to revise the current conception of what professionalism means, not only in art, but in any other kind of creative work. In this paper I intend to single out one harmful aspect of pseudo-professionalism—its insistence that a competent craftsman ought to visualize clearly both the product and the production process.•

The demand for clear visualization is not confined to the visual arts; it vitiates also the teaching of music and in a somewhat different form the teaching of science. In music the proficient composer is expected to visualize the final sound of his composition without checking his progress on the piano; in his inner ear he must anticipate precisely how his work will sound in actual performance.

The usual moralistic attitude creeps in. Modern composers of serialized music are blamed for not caring enough about final sound effects; they are reported to construct their complex permutations of serialized elements for purely intellectual consideration without even trying to visualize their sensuous sound qualities. In the same moralistic vein are anecdotes, possibly true, about contemporary composers failing to spot wrong notes in the performance of their own work. This main concern with the mechanics of the working process and relative indifference to its end product also characterize modern painting. Action painters, almost by definition, are supposed to be concerned only with their muscular action without anticipating the precise outcome of their virtuoso performance. But I feel that to a certain extent this indifference for the future must be an ingredient of any original work. If we are exploring really new territory, we cannot always chart clearly the way lying ahead. We should be prepared to go even further and maintain that an excessive need for looking too far ahead into the

• The author discusses at length the theoretical basis of this paper in his article, "The Undifferentiated Matrix of Artistic Imagination", in *The Psychoanalytic Study of Society,* International Universities Press (1964).

unknown may damage the efficiency of our search. The psychological need that underlies the anxious academic demand for total visualization will therefore not merely block the free play of imagination; it will harm technical competence itself. This demand ought to be eliminated from our concept of professionalism in creative work.

In a somewhat different form the demand for precise visualization also exists in science. The scientist is expected to define his concepts in advance so that he is fully aware of all he is thinking and arguing about. But if he ventures into a really new field it may well be impossible to know in advance what new concepts will become necessary. To begin with, he may have to make do with tentative terms, the precise meaning of which will be clarified only by their subsequent use. In the invention of new mathematical proofs the end result may be defined but not the way leading to that result. Euler, who was particularly inventive in producing new proofs, often introduced new and in themselves quite meaningless symbols. Their precise function only emerged after they had produced the desired proof by devious routes. Creative thinking, then, in science as well as in art, presupposes a mysterious capacity for operating precisely with imprecise structures. The creative thinker has to take steps and make interim decisions without being able to visualize their precise relationship with the end product. Yet somehow he manages to extract from such half-baked structures information far in excess of their face value and so is capable of making the correct decisions and choices all along the route. His lack of precise visualization is bound up with the fact that creative work opens up new avenues of further progress at each step. These endless ramifications may be astronomical in number. He cannot possibly examine all these future possibilities and make a conscious choice. Conscious visualization can only deal with one alternative at a time. Hence he must rely on unconscious intuition for scanning these many possibilities. I will maintain that unconscious visualization has a wider focus and so is capable of scanning with a single glance all the many ramifications of the way ahead and assists in making the right choice. Hence the assistance of the unconscious mind is not merely needed for a greater measure of imagination, as is commonly assumed, but is indispensable for efficient work, owing to the superiority of unconscious scanning over conscious visualization.

The description of scientific and mathematical thought as a gradual advance in several stages, each of which opens up new avenues of further progress, also fits artistic work. An American critic once complained to me about the usual concept of action painting as painting exclusively concerned with muscular action. In truth, he said, the action painter works in several consecutive stages, each of which imposes on him the need for new choices that he could not have foreseen at an earlier stage. I hope that by now the reader will have come to suspect that this description fits almost any kind of truly original work. Other examples readily come to mind. Stanley W. Hayter, the pioneer of modern engraving methods, once described in a lecture how he overcame in his teaching the mechanical professionalism of traditional engraving. He would tell his pupils to work in successive stages without pre-planning the whole composition. Each stage introduced a new motif or new technique. They were first to invent a single motif, then balance it with a counter motif that gave enriched meaning to the first, and add step by step new ideas and techniques. There was a mysterious logic and cohesion between these stages. Each step was equally crucial for the final allover structure, even though its relationship to the end result could not be precisely visualized. If the student took the right step, it would enrich and quicken the flow of ideas, while the wrong step brought the whole process to a premature standstill. The student had to acquire a capacity for making the right choice though the information needed for that choice was not at hand.

But, as I have tried to indicate, this paradox is resolved if we consider that only our conscious information may be so limited; the necessary data may be available to our unconscious mind, which has to guide us in making the right choice. Concerning the curiously vague structure of our guiding visions, William James, the American psychologist-philosopher, commented that, between the precise images crystallizing in our thought stream, there are interspersed transient stages of vague visualization that guide the emergent future image. This guidance, though vague in structure, is sure and imperative in its function. William James was only a precursor of psychoanalysis; he could not therefore make full use of the concept of unconscious mental functioning. Today we can say that the stream of consciousness oscillates between different levels of mental functioning. While on a conscious level we seem to operate with vague and half-baked images, no such vagueness need exist on a lower level, where structures that would appear ambiguous to our conscious mind can be grasped with firmness and precision. This is the reason why in creative work we have to make our conscious visualization purposely vague and ill-defined so as to bring into action the more efficient scanning process of the unconscious mind to guide us in our search. Our conscious experience may seem vague and blurred, but only so because it cannot cope with the more comprehensive imagery of low-level vision.

The classic example of low-level imagery is the dream. Our conscious recollection is often quite incapable of dealing adequately with the more broadly structured images of a dream. The dream thus impresses us as being vague. While we are dreaming, certain dream images can come with exceptional freshness and precision. After waking we may begin to doubt them. In fact, the more we strain our conscious attention, the more will its pinpoint focus contract and be less capable of containing the broader structures of the dream. These structures recede before our searching glance and in the end dissolve into a white fog. In my view, this vagueness of our dream recollection cannot be blamed on the original dream, but rather on the narrower focus of our waking attention which willy-nilly serves us for examining the dream memory. The *Gestalt* psychologists have a word for this tendency toward precise focusing; it is the famous *Gestalt* principle. In my opinion, however, this tendency does not hold good for lower, unconscious levels of vision, where our focus broadens out. If, after our abortive attempts to catch an evasive dream image, we allow our attention to relax, its narrow focus may automatically open up into the wider all-comprehensive stare that is nearer to dreaming and reverie than to waking. Then out of nothing the mocking dream images may return with their old vigor and precision restored. If, in creative work, we make our vision intentionally vague, we will induce the same shift in the structure of our attention and force our vision down to the unfocused state of attention which is so much better equipped for scanning the far-flung ambiguities met in any creative search.

James Joyce in an early, clearly autobiographical novel described an astonishing feat of split-second scanning performed in a reverie-like state of mind. The hero of his novel listened to a soporific sermon. As his attention flagged it began to play with the single words of the sermon. He would arrest a sentence half-way and in an instant complete it in a number of variations long before the preacher himself had reached the end of his sentence. Such a feat is prodigious and involves the scanning of several mutually exclusive possibilities at a single glance. Of course, normal waking attention is far too slow to serve in such a split-second game. Thanks to the *Gestalt* principle the pinpoint of our conscious attention can only deal with a single variation at a time and would be quite unable to enclose several variations in a single glance as James Joyce's hero would have done. It is extremely difficult, if not impossible, to imagine the structure of a perception that contains several mutually exclusive variations of a theme in a single act of comprehension. For lack of a better word I would like to call this kind of perception the "or-or" structure of low-level vision. Low-level vision is not forced to make a choice between contradicting patterns but holds them in a single glance.

In dreams we may meet with weird apparitions which are neither this nor that, but everything all at once. They are not condensations in the psychoanalytic sense in that they would borrow single features from incompatible things and compress them into a surrealist composite; no, the severally mutually exclusive things coexist in their entirety. Owing to the pinpoint focus of conscious vision I cannot, of course, demonstrate these or-or structures to the reader except by referring him to his own ineffable dream memories. We can only adduce their existence from the facts of creative vision, which has to hold mutually contradicting views in a single act of comprehension in order to be efficient. When the mathematician has to scout several mutually exclusive avenues of further progress he does not examine them one by one, but chooses his route by a single act of intuitive choice.

Similar or-or structures can be inferred from other not necessarily creative activities. For instance, in reading a crime story we are presented with ambiguous material that forces us to scatter our attention. In real life a detective has to follow up ambiguous clues one by one. The reader of a crime story is not given so much time. He has to follow the several chains of mutually exclusive clues in a state of undivided attention which is nearer to dreaming than to waking. No wonder that crime stories can be thrilling and relaxing at the same time. Their plots may keep us in breathless tension, yet their ambiguous or-or structure affords us relaxation from the single-track way of thinking by which we have to conduct the daily business of our lives. The same relaxing concentration is found in combination games like chess or bridge, again owing to the existence of or-or structures. The card player at any stage of the game must evaluate the many possible distributions of the unplayed cards held by his fellow players. I myself, being an exceedingly awkward player, have to consider every single possible distribution one by one and, of course, usually end up by making a wrong decision. The good player, gifted as he is with a mysterious card sense, can scan and evaluate all possible permutations in the distribution in a single glance. These permutations can run into very high numbers and are typical or-or structures which could never be satisfactorily examined on a conscious level. If we were to ask a card player what was actually in his mind as he weighed the situation of the game he would probably be unable to tell us, for the simple reason that his conscious attention was blank and blurred while unfocused scanning was going on on deeper mental levels. Any attempt here at more precise visualization would be as harmful as it is in creative work. If, at the crucial moment of decision, we try to size up our situation too clearly, we will automatically narrow the scope of our attention and so deprive ourselves of the faculty of low-level scanning on which the right decision depends.

Though or-or structures occur in combination games as well as in creative work there is, of course, a fundamental difference between them. In playing games the rules of the game strictly limit the number of choices, however many. No such limiting rules exist in truly creative work. Though the fertility of a motif depends on the many choices still lying ahead, there exists no rule by which we can evaluate its ultimate effect and development: the work itself creates its own rules. Thus an unlimited number of choices have to be scanned according to rules that will define themselves much later. A fully conscious analysis of the fertility of a motif is impossible even where conventional rules exist for its development. The sonata and fugue forms depend on such conscious rules. Choosing a good fugue theme can be of crucial importance, but no rule will help in making the right choice. The composer, in order to judge its suitability, would have to scan intuitively the complex polyphonic textures into which the theme will interweave with itself. Johannes Sebastian Bach was greatly admired in his own time for his uncanny gift for inventing or choosing good themes. So amazing seemed his facility to his contemporaries that he was credited with the possession of a secret family recipe handed down through generations of the great Bach family. There was, of course, no such recipe. This anecdote brings out a tacit acknowledgement of the fact that rational analysis alone cannot judge adequately the future fertility of a fugue theme or indeed of any creative motif.

A fertile motif will often bear the imprint of the *Gestalt*-free dreamlike vision which shaped it. There may be something sketchy and vague about such a theme that refuses immediate aesthetic satisfaction and instead points to the future for its fulfillment. Once we have listened to a complete performance of a piece of music we will no longer be bothered, in retrospect, by the theme's frayed edges and unfinished sound; they are now justified by the later developments which must have pressed around it from the beginning and prevented it from setting hard too early. Because our normal faculties are ruled by the narrow focus of the *Gestalt* principle, it is not easy to prevent the premature crystallization of a theme. It is as difficult to hold on to the original ill-defined and open structure of a good theme as it is to invent it in the first place. The "law of closure" postulated by the *Gestalt* psychologists will tend to round off its frayed edges and so cut off its creative development. Fortunately the creative thinker is at home in those deeper mental levels where the *Gestalt* law of closure does not hold good. For him an insignificant scrap of melody or some accidental-looking bit of texture is far more likely to contain the key to the evolving allover structure of a work than a well-rounded melodic phrase or carefully composed pictorial pattern. It is accepted as a generally valid educational principle that the art student must learn to resist the attraction of some happy detail; he must be able to destroy it in order to safeguard the integrity of the whole. An aspiring poet must learn to delete a resounding purple phrase as much as the composer must resist the lure of rich sound and melodiousness, all of which appeal to our conscious craving for rounded, well-clipped *Gestalt.*

I do not want to be misunderstood. I am not making out a case for the virtues of inarticulate Tachist scraps as against precisely constructed compositions. It is not the objective structure of the motif which concerns us, but its psychological subjective role in creative work. If a motif possesses objectively a precise and focusable *Gestalt,* the creative thinker has to transform it in his subjective visualization into more malleable material akin to the ambiguous or-or structures of low-level vision.

Very instructive for a better understanding of this transformation is the example of textile design. Though usually considered and practiced as a humble branch of commercial art, its technique requires unusual powers of visualization. The textile design is a motif in the true sense; it requires development into a richer final effect, in this case the allover texture of the cloth into which the motif fuses as it is repeated over a larger area. This allover effect is qualitatively different from the single motif. The textile motif resembles a fugue theme in that it is only realized by being fused with its own replicas into a kind of polyphonic structure. Looking at a single motif as a pretty little image in its own right will not help to visualize its development through the repetition. The designer must be capable of looking at it in a twofold way. The design motif is at the same time a self-contained image offering aesthetic satisfaction, and also a creative motif that can only fulfill itself by being obliterated within the final allover effect. Excessive pleasure in the motif as an attractive self-contained image may impede its more important evaluation as an inarticulate growth element from which the future allover texture will grow. Instead the designer must blot out in his subjective visualization the motif's too precise *Gestalt* and transform it into a blurred, almost shapeless scrap that will win aesthetic merit only in its final obliteration. To achieve this change in subjective attitude he must learn to disperse his attention into the unfocused stare that alone is capable of scanning in advance its many possible transformations.

Perhaps the neatest or-or structure in any art is found in Schoenberg's twelve-tone row. For Schoenberg the twelve half tones of the chromatic scale in all their possible permutations represented his eternal theme. In order to evaluate the future potentialities of a given tone row the composer must evaluate its innumerable permutations in advance. This, for reasons we have stated repeatedly, cannot be done by conscious analysis alone. We have to credit Schoenberg with a faculty of grasping the or-or structure of any given row in a single act of comprehension. As in the case of Bach, the reaction of Schoenberg's contemporaries was psychologically revealing; in this case, however, the reaction was hostile. His critics complained, quite rightly, that it was impossible by ordinary means of conscious appreciation to recognize whether the law of the twelve-tone row was in fact observed. They missed the point that the law, though intellectually conceived, aimed at defeating all intellectual analysis. Here is a case of rationality turning against itself. It is not Schoenberg's fault that his disciples now apply his law as a purely conscious device for assembling fully predictable and mannered structures. I will later mention other examples where spontaneous techniques become deliberate assembly devices.

It is fatally easy to copy originally spontaneous techniques. Action painting certainly arose from a disruption of conscious methods of composition. For the first time in the history of art, painters came close to acknowledging consciously the key function of inarticulate scraps and bits of texture. Within a short time action painting degenerated into a deliberate assembly of decorative textures in which their proper structural function was not considered. The demise of action painting proves that a preference for inarticulate scraps and bits does not guarantee their sensitive use as fertile motifs. As I said, it is the subjective attitude alone that counts, i.e. the shift of attention to lower intuitive levels.

I have also suggested that the aesthetic appeal of precise geometric material makes this shift more difficult. A few years ago certain English universities sponsored an art-educational exhibition at the London Institute of Contemporary Arts that recommended the gradual development of complex structures from simple precise elements. The development resembled the deductive method of developing Euclidean geometry. The student was to start with exercises done only in dots, go on from there to drawing in lines, develop two-dimensional surfaces from these, and at last project these flat designs into solid three-dimensional objects. There is certainly virtue in making the student aware that any shape, however complex, can ultimately be built up from the simplest elements. This awareness makes for clean athletic design. But the awareness of basic elements could also be misused as a fully conscious control of the entire working process. An excessive preoccupation with the geometric constituents of a design could make the student ignore the drastic transformation which the single elements undergo as they fuse into a more complex allover structure. As always this final structure cannot be predicted from a conscious analysis of the single elements and steps that went into building it. A too conscious handling of the single elements prevents the development of the intuitive capacity for scanning the emergent allover structure. We know by now that unconscious scanning is only possible if the student learns to temporarily blot out his precise conscious visualization in order to give his intuitive-unconscious faculties freer rein.

One feels that the attraction in the precise handling of precise geometric elements may be reinforced by the pseudo-scientific attitudes that are current among contemporary artists. It is all the more important to realize that the rigor of mathematics and science is not related to a need for precise visualization. Of course education in any discipline may usefully start with a fully conscious analysis of elements of rules; but at a certain crucial point which has to do with the awakening of creativity, the student has to learn to turn about resolutely and blur his conscious visualization in order to bring into action his deeper faculties. This is true of the grammatical rules in teaching languages. In language teaching it may be justified to start by training the student to assemble sentences from the basic elements of language according to the rules of syntax and grammar. But if the student is too content with the mechanical assembly of his sentences he may fail to grasp the spirit of a living language, which can only be comprehended by scanning the unlimited range of constellations into which words are fused in daily use. This scanning, of course, cannot be done by conscious analysis and reassembly. It depends on the psychological constitution of the student as to whether is would be dangerous for him to start with grammatical analysis of elements rather than with an intuitive study of sentence structure.

In the teaching of the most rigorous of all disciplines, mathematics, we come across the same problem. The mathematician Hadamard has been much concerned with the psychology of mathematical creativity and the shift from conscious to unconscious control. In teaching mathematics, too, one has to start with conscious control and analysis. The student has to train himself in what we would now call the "grammar" of mathematics, i.e. the application of the conscious rules by which a mathematical argument is built up step by step. The overanxious student will be exclusively concerned with checking each step according to the rules. But such conscious checking does not suffice for creative mathematics, where we have to compare the whole structures of arguments and evaluate their relative efficiency. I mentioned earlier how a mathematical argument proceeds with interim stages and results, each of which branches out into several possible avenues of further progress. Only a few of these will prove fertile, and must be scanned in advance. These mutually exclusive avenues of progress represent a typical or-or structure and thus baffle our conscious powers of visualization. If the student of mathematics is too anxious to retain conscious control, his attention remains riveted on the single steps of his argument and he will miss the essential allover structure of the argument. Hadamard maintains categorically that the creative thinker has to blot out his precise visualization in order to keep proper control. Hadamard follows Poincaré in assuming that this control is taken over by lower, usually unconscious levels of the mind. Vagueness of visualization is no virtue in itself; it succeeds to the extent to which control is shifted to lower mental levels and that unfocused type of attention which is so much better equipped to deal with ambiguous or-or structures.

Hadamard thinks that the use of neat diagrams as visual models for geometric arguments obscures their complexity. He reports how he himself has learned when using diagrams to resist their tempting simplicity. He would blot out of his vision the view of the whole diagram and instead concentrate on some detail which was meaningless in itself.

Hadamard suggests that Greek geometry declined in post-Classical times because of too precise visualization. It produced generations of clever geometers and computers, but little further advance in theory. Descartes broke the deadlock by doing away with geometric visualization altogether; he invented analytical geometry, which expresses geometric relationships in numbers only. Today, non-Euclidean geometry no longer permits the visualization of a stable space grid; it is replaced by the dynamic interacting between several shifting space systems. No wonder that geometric space intuition is considered the rarest of gifts.

Architecture is to the other arts what geometry is to other branches of mathematics. It offers the greatest temptation to visualize in precise, neat diagrams, elevations, ground plans etc. While we can avoid the premature introduction of geometric elements into basic-design teaching, this is not possible in teaching architecture. Space intuition is therefore as rare in architecture as it is in geometry. Architectural space is too easily visualized as a static and rigid grid of quadrangular boxes with little sensitivity to the dynamic interaction set up between shifting space systems. The present international style is little more than an assembly of rigid box units into entirely predictable, stylish façades. To avoid creative sterility it is as necessary in architectural design as it was in geometry to deflect one's attention away from static space to the dynamic fluid interaction between several space systems. A young architect friend of mine told me how he deliberately concentrated on the flow patterns in which the traffic of people and goods would circulate between the space units rather than on the space units themselves. There is also a simpler way to break up the static concentration on box spaces which corresponds to counterchange exercises in basic linear design (Fig. 1). In such counterchange exercises the designer is required to draw patterns where the figure-background relationship—as investigated by the *Gestalt* psychologists—becomes wholly ambiguous. If the student paints dark patterns, the white background left outside ought to make equally strong and significant patterns. According to *Gestalt* psychology one can only concentrate on either the figure or the background. But the student is expected to control them both simultaneously as he draws a single line that defines the pattern within and the background outside. Making one's attention jump between the two alternative modes of configuration will not do. Instead the student must learn to wipe out all precise visualization and to comprehend both mutually exclusive possibilities—a typical or-or structure—in a single glance: another neat demonstration of how an empty stare can prove technically more efficient than precisely focused visualization. In architecture too the simplest device for breaking open the tight box-space units is to realize the fundamental interaction between inside and outside space. Every wall not only defines the space enclosed within but also the space without. In this manner the little boxes contained in a building begin to act on each other and on the environment.

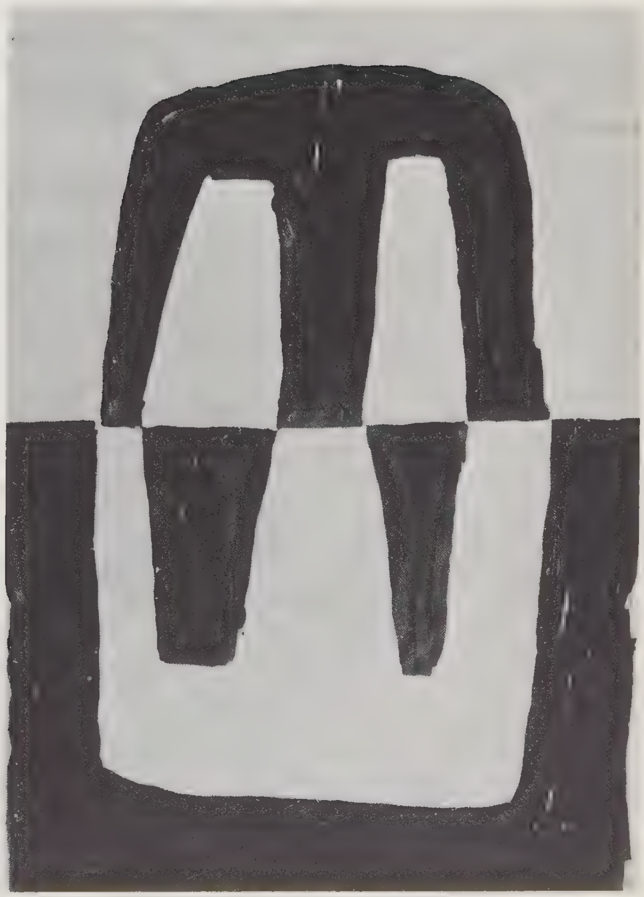


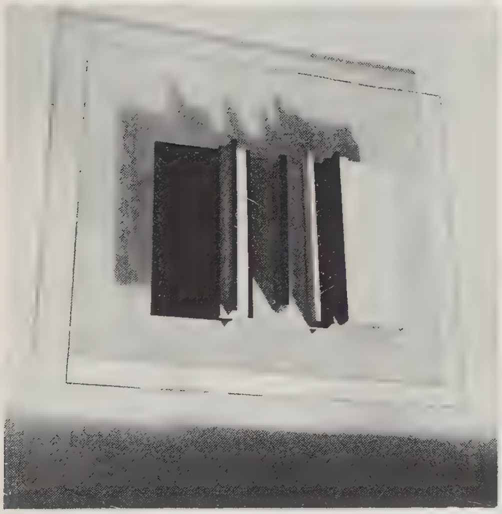
Fig. 1. Simultaneous Control of Figure and Background: Counterchange Exercise. Basic Design Course of W. Turnbull, London Central School of Arts and Crafts.

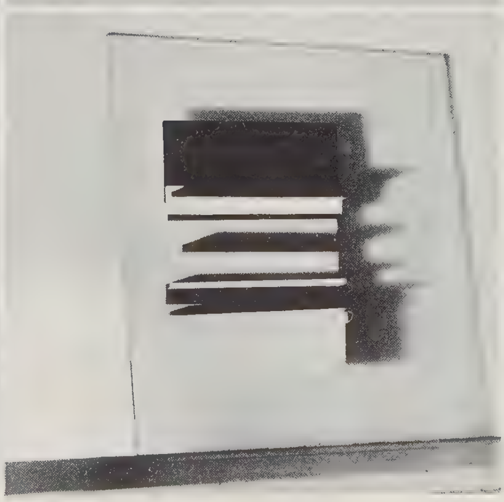
Architectural space intuition must scan complex interactions which to a purely conscious analysis easily seem accidental and imponderable. It is never entirely possible to anticipate with any precision the impact of changing illumination and perspective distortion playing on cavities and protrusions of a building. The simpler and more geometric architectural shapes become, the more dramatic and incisive appear their irregular distortions wrought through changing light and viewing angles. Mies van der Rohe's influence on his disciples has been largely harmful because his disciples are fascinated by his stark simplicity and the ease in which such buildings can be put together, without sharing his sensitivity for the many complex variables that determine their final appearance. That these variables cannot be precisely visualized in advance, and successfully resist computation as functional factors in deliberate planning, does not make them less significant. They present a challenge shared with all creative work.

Precision also invites complexity in other fields. At the beginning of the nineteen-fifties the British painter, Victor Pasmore, until then a Post-Impressionist painter of repute, turned to an austere constructivism, impelled, as he said, by a need to construct space with greater precision. Even Cubism did not afford this precision and he was forced into constructing three-dimensional objects. When he had reached an extreme of simplicity and precision in the construction of space, a sudden transformation set in that brought his austere constructions to life (Fig. 2). He had arranged a number of painted wooden slabs vertically in front and at the back of a transparent sheet. The picture plane of his former paintings had, as it were, become transparent to allow building out into space in two directions. The transformation of these simple arrangements was due to the impact of the variables of light and viewing angles. As the light reflected from the glass crept into the crevices between the slabs and highlighted the protruding surfaces, as perspective foreshortenings formed a "sky-line" zigzagging between the receding and advancing slabs, an impression of utter complexity and variety was created. As Pasmore himself admitted, after many years of self-imposed austerity his old Post-Impressionist love for light impinging on space had once again asserted itself.

Fig. 2. Changing Illumination and Viewing Angles. Victor Pasmore, *Architectural Construction*, 1955.





There is no reason why the variables of light and perspective should not be made the object of more systematic study. Characteristically such study is not undertaken in professional training, but is relegated to unspecific basic design. Gyorgy Kepes, while teaching visual design at the Massachusetts Institute of Technology, demonstrated to architecture students the dramatic impact which changing illumination can exert on simple spatial arrangements (Fig. 3). One of his exercises used a pegboard that had to be studded in absolutely regular intervals by cylindrical pegs that differed only in their length. It seems hardly possible to obscure the simplicity of this arrangement with the effects of illumination. Yet Kepes, by lighting up the pegs from different angles, produced patterns of a variety that seemed to have nothing in common. Such transformations seem inaccessible to rational calculation. Yet on a bigger scale the final effect of any building depends on such unpredictable variables.

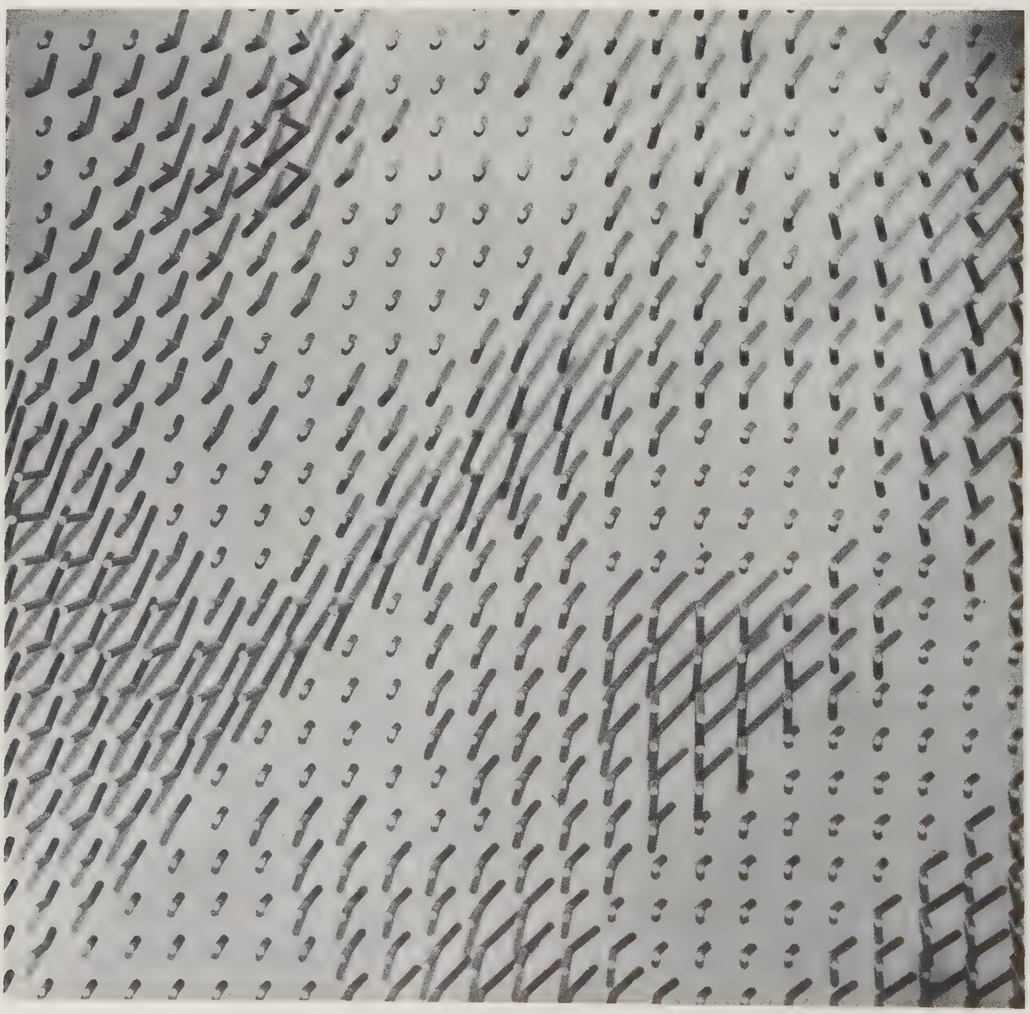
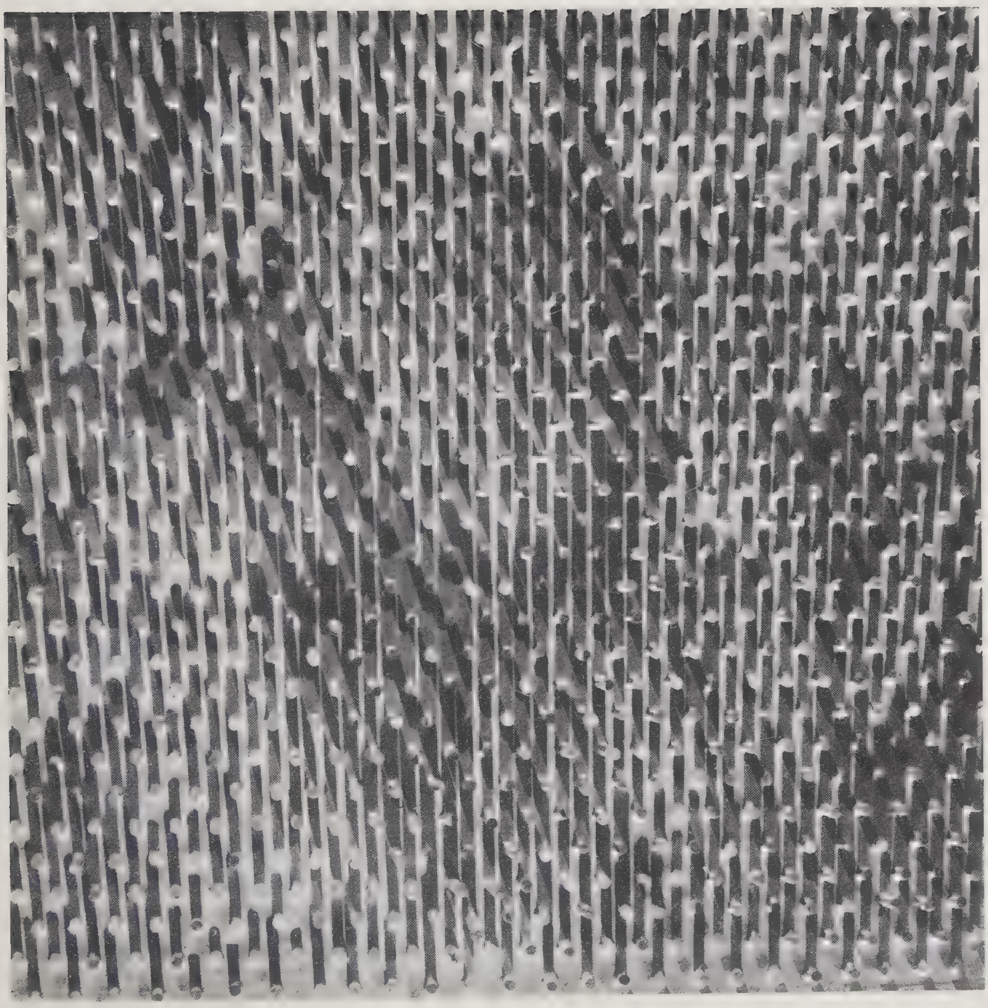


Fig. 3. Changing Illumination and Object Identity.
Basic Design Course of Gyorgy Kepes,
Massachusetts Institute of Technology.



Different coloration can also obliterate the identity of the object. Josef Albers made this conflict between color and object identity the main subject of a recent work. In his series of paintings *Homage to the Square* he subjected a very simple flat design of squares of diminishing size to the impact of different coloring. The resulting tension between the color surfaces made the previously flat picture plane bulge and billow, now extruding the smallest central square, now pushing it far back into the background. This manipulation of space is not entirely predictable and not accessible to an exhaustive rational analysis. This is perhaps the reason why a bold use of color is feared by the rational type of designer. Architects generally shy away from the possibility of distorting their precise space constructions by the application of strong colors, the effect of which they cannot fully anticipate. They usually play safe by doing without color altogether.

In a very similar way the effects of glazing and colored decorations may alter the identity of a good pot. The average potter finds satisfaction in throwing his pot expertly and is not quite prepared to have its clean lines affected by the partly uncontrollable effects of glazing. Picasso, through exuberant decoration of his pottery, transforms a traditional shape into a fantastic near-human figure. The average potter is irritated by what he considers to be Picasso's lack of craftsmanship. It is of course the acme of good craftsmanship to be capable of going on from an interim result—and the unglazed pot is only an interim result—to final effects which cannot be fully anticipated. His power of transforming a pot has certainly made Picasso into the most important potter of our time. It is unfortunate that the average potter interprets the duty of a good craftsman as a need for keeping the working process under fullest conscious control. As this control can only be exerted during the throwing stage of the pot, decorating comes as an afterthought tinged with anxiety about the partly accidental final effects.

Architecture has been more heavily affected than any other art by the misunderstanding of what technical competence means. As I have said, modern architecture in its excessive need for conscious control is often little more than the assembly of tight box-space units into stylish allover structures. The creative bursts in the recent history of architecture broke the hold of mannered formulas by inventing certain disruptive devices that helped to stem the usual headlong rush to some predetermined solution. For a time any newly discovered functionalist factor had this beneficially disruptive effect. As a general principle functionalism seems to preach a purely rational, conscious approach to design. But functionalist factors, as long as they were still new, could complicate the designing process and make its eventual result uncertain. The earlier technological type of functionalism utilized the technological limitations imposed by new building techniques and materials in order to arrive at new solutions. But modern techniques proved so flexible that they could soon be made to conform with any preconceived structure. Today architects in search of inspiration are casting around for new sociological factors that would introduce welcome obstacles into their calculations. So great is their need for this new sociological functionalism that they are often not content with serving the existing social order, but find themselves in the role of social reformers catering to non-existing social requirements. I am not deprecating this new kind of functionalism. Even if spurious, these factors serve their psychological function in the creative process by disrupting existing clichés. Le Corbusier's *L'Unité d'Habitation* at Marseilles may have failed as a social experiment, but it certainly succeeded in modelling a new architectural shape.

Le Corbusier invented another creative catalyst in his *modulor*. The *modulor* too acted disruptively; it prevented him from starting his design from the outer shell of the building like a stylish façade. Instead he had to develop his design from within, starting from the smallest unit, the *modulor*. For a time Le Corbusier hoped to have invented a permanent recipe for good design. But it worked only as long as it disrupted the direct course to some preconceived façade. As a disruptive device the *modulor* was as shortlived as the various functionalist factors. Le Corbusier's faithful pupils soon learned to make a most facile use of the *modulor* and assembled its units into very much the same kind of buildings they had built before. We have met with a similar transformation of disruptive devices into assembly devices when we discussed Schoenberg's twelve-tone row. I mentioned how Schoenberg himself had used the row in order to disrupt all consciously comprehensible continuity and so arrived at new exciting solutions. His followers soon turned the row into a mechanical assembly device that produced in due course the same monotonous zigzag phrases everywhere. In psychological terms this transformation reverses the fundamental shift in creative work from conscious to unconscious control. Intuition is once again replaced by rational planning.

It is not evident why intuition and rationality should not work in harness instead of fighting each other for exclusive control. Our civilization seems to be affected by a profound dissociation of (conscious and intuitive) sensibilities to which writers like T. S. Eliot, Sir Herbert Read and recently Erich Heller have drawn attention. Unfortunately a vicious circle operates. Because conscious-rational control tends to become intellectualized and excludes the participation of the rest of the personality, the excluded unconscious-intuitive functions have to act disruptively by forcing their way up and casting aside completely all conscious control. Utter spontaneity then replaces the former intellectualism. The defeated conscious faculties fight back and, by what psychoanalysis would call a secondary process, reimpose conscious control on the originally disruptive techniques. In this manner disruptive spontaneous devices are transformed into assembly devices amenable to deliberate planning.

This transformation seems unavoidable and forces the creative artist to invent ever new techniques of disruption such as I will discuss later. An amusing counterpart to the quick demise of the *modulor* as a creative catalyst is afforded by an earlier episode in the history of music. I am referring to Richard Wagner's *Leitmotiv*, which served the master so well, but failed to fulfill the hopes it first aroused. The *Leitmotiv*, like the *modulor*, arrived as a disruptive device; it broke up the traditional set pieces of operatic construction—the neat sequence of arias, ensembles, duets and so on—and forced Wagner to reconstruct the large-scale structures of opera from within, starting with the smallest unit. Wagner related the *Leitmotiv* organically to the dramatic needs of the plot and joined the single motifs according to the evolving dramatic situation. For Wagner himself the emerging structures and sound effects remained unpredictable. When in *Götterdämmerung* he used motifs that he had invented twenty years earlier in his *Das Rheingold*, he felt filled with awe and wonder at the novelty of the sound which he was capable of eliciting from the familiar material. Not so his disciples. For them the *Leitmotiv* became an instrument for assembling another conventional form, now the Teutonic "music drama". All that was needed was to invent a number of expressive themes related to the plot, and string them together; certainly the much vaunted unity of the music drama was thus assured, yet it failed because its assembly of motifs led to entirely predictable results in the sonorous Wagnerian style.

My contention that the final allover structure may come as a by-product of work done from the inside follows logically from my earlier description of creative work as work done in interim stages that cannot always be firmly connected with a final result. In music generally the inside structure is represented by the hidden polyphonic structure which is ultimately clothed by sonorous harmonic sound. The composer is exposed to failure if he aims right away at sonorous fullness of the harmonic sound. This is why the often voiced demand that the composer ought to visualize precisely the ultimate sound effect of his work may lead the young musician astray. A composer who aims primarily at a good harmonic sound effect and then proceeds to fill this sound with variegated polyphonic texture, cannot do really good work. The ultimate failure of Delius may have to be explained by his primary aim at a full, sensuous sound. Instead, the good composer should deflect his attention from precise harmonic sound effects and disperse it among the hidden polyphonic voices. This requires the unfocusing of attention that is common to all truly creative work. Attention to harmonic sound can be described as the normal conscious experience of music; on the other hand attention to the ambiguous or-or structure of the polyphonic web represents the unconscious portion of the musical experience. As the control of the polyphonic structure is the principal technical task of composition, technical competence in music is clearly dependent on the lapse of an exclusively conscious control and the activation of lower, unfocused levels of perception. It is not easy to confirm by direct introspection that the unfocused polyphonic type of hearing is really empty and "unconscious" in contrast to the normal listening to harmonic sound.

I remember an amusing discussion among some young musicians as to their relative capacity for listening to several voices at once. They obviously thought that polyphonic listening required a fully conscious attention to all polyphonic voices simultaneously. One of them admitted ruefully that he at best could follow only two voices sounding together. Another claimed that he could include a third voice as well. Significantly none of them reported that he could keep track of all the four voices which are the normal complement for a full harmonic sound. If we observe ourselves more closely it becomes apparent that it is impossible—on a conscious level—to divide one's attention even between two voices, unless of course one makes it jump between them in an unsuccessful struggle to catch up with each of them. But this is surely not the way to appreciate music. Those young musicians confused their facility for extracting the hidden polyphonic voices from the normal hearing of harmonic sound with a capacity of actually hearing all the several strands of the polyphonic voices sounding together. Polyphonic hearing is as empty for the musician as it is for the layman, but from this emptiness the musician can elicit all the information he needs through the agency of unconscious scanning which I have described.

The trained musician allows his attention to oscillate freely between the two types of attention, once focusing precisely on melody and sound, once returning to an unfocused stare spread out among the several polyphonic voices. To a certain extent the layman's listening to music partakes of this oscillation, guided by the constantly changing emphasis on the single sonorous melody or polyphonic texture. Single dissonant tones within a chord may disengage themselves for a while from the thick harmonic sound and claim attention as part of a hidden polyphonic voice, but will sink back instantly as the dominant melody claims attention. This smooth oscillation between focusing and unfocusing will soften the usual rigid dissociation between conscious and unconscious faculties, and so afford a kind of mental gymnastics that is helpful for a better integration of our personality. The two types of attention will yield to each other without the violent mutual disruption of sensibilities that has made the recent history of the arts so turbulent. A similar integration of conscious and unconscious sensibility will occur in those happy phases of creative work where fertile ideas come forward willingly without the pressure of pain and anxiety.

I said that a pleasing sound effect is not the primary aim of good work, but merely the welcome by-product of a well-made inner structure. It is the hallmark of great art that it is not dependent on achieving precise sound effects. By being open to an unlimited number of interpretations it retains a measure of ambiguity and the or-or structure characteristic of the unconscious mind. This residue of indeterminacy may exist even if the artist has in fact aimed at a more precise effect. Yet as we have seen, academic teaching does not tire of extolling the virtue of aiming precisely at the work's final effect. Music teachers back their demand for precise visualization by the awe-inspiring example of the deaf Beethoven, who could write revolutionary music in spite of his infirmity. But there are indications that Beethoven did not in fact care very much about the sound quality of his late work. In his maturity he paid increasing attention to polyphonic construction, and even took lessons in counterpoint in order to heighten his polyphonic sensitivity. Accordingly, his late music often lacks in sensuous sound quality and sonorous melody; it can even be tinny and hollow. His late piano sonatas often make the player's hands move so far apart that the metallic jingling of the right hand refuses to mix with the rumbling bass, a most disagreeable experience for the average music lover who likes his music full and sonorous. So great is our need for a plastic, melodious sound, that some conductors cannot tolerate certain passages in the *Ninth Symphony* where the melody fails to ride the surge of the polyphonic texture and they do not hesitate to re-orchestrate those passages in order to give the melody its due weight. In doing so they pander to the common addiction to thick sonority, but to the same extent they may well have weakened original intentions of Beethoven, who himself focused less and less on melody and harmony, and sustained his faculty for dispersed, unfocused hearing over long stretches of his symphonic work.

I was at pains earlier to emphasize that as far as the working process is concerned the lapse of precise conscious control greatly improves technical efficiency. We now see that this is true also of the end product. The creative thinker may consciously aim at a precise target, but this precise aim need not interfere with the possibility of a broader interpretation. Modern architects are wont to say that their building may serve a transient, temporary purpose and they are content that it should be pulled down as soon as this specific purpose has become outdated. I feel that in spite of such modesty a good work will always prove far more flexible. Unknown to the designer himself, his unconscious mind will have scanned and explored many other uses and interpretations and automatically provided for them in the final design. The rigid geometricity of the present international style in architecture proves inflexible to any broader usage. The London architects Peter and Alison Smithson, in their exposition of "new brutalism", criticized the functional inefficiency of neat precision in design. They say that the business of living is messy; as it impinges on a too neatly designed space it will throw it into confusion and ugliness. A well designed block of popular flats ought to be enlivened, not disfigured, by the many-patterned curtains that its future occupants will put into the windows. Any really good building ought to be "open" in the sense in which a fertile motif is open, waiting to receive readily the not entirely predictable incidents of its practical use that will produce its final appearance. One could even say that the final result of creative work remains to a certain extent an interim result that cannot define precisely its ultimate interpretation.

The general applicability of this principle can be illustrated from more distant spheres of human planning. Precision of expression and interpretation is perhaps most important in legal language. Yet it is known that contracts that are too detailed rarely meet the needs of the parties who are affected by not entirely predictable future developments. A new statute that is too neatly tailored to meet the needs of the present time will immediately be made obsolete by the inevitably swift changes in our economic and social conditions. Because legal professionalism puts a premium on precision and comprehensiveness, trained lawyers rarely make good legislators. A good law, in order to be efficient, must retain the raw edges and openness of good planning. Napoleon was a better lawgiver than the German theorists who had labored through the nineteenth century to extract precise legal terms from the existing laws. At the turn of the century they were given their opportunity; the codification of the German civil law was entrusted to their learned hands. Promptly they incorporated their precise and coherent concepts into the body of the law itself, hoping to ban forever doubt and imprecision in its application. As we would expect, they failed lamentably. Through their very precision and neatness their statutes were unable to meet the needs of a changing society. To provide for future accident and the unknowable is very much the faculty of unconscious scanning and not of conscious planning. The more broadly conceived or-or structures of the unconscious can absorb even accidental factors and give to the final formulation that raw open edge that reaches out into the unpredictable future.

In a way the scientist, in framing his laws of nature, is in the same position. His scientific experience has taught him that his knowledge must inevitably remain incomplete. Paradoxically therefore, in order to be precise in his approximation to objective truth, he must keep his formulations purposely open and in another sense imprecise. Only so can he provide for the yet unavailable factors that are known to exist. Conscious *Gestalt* tendencies will mislead him and he will have to rely on the broader focus of low-level vision that alone can supply him with the ambiguous formulations (or-or structures) that will not be falsified by the new factors expected to come to light. These open, partly undetermined formulations may describe the always incomplete state of human knowledge more accurately than the clipped and all too neat formulas of intellectualized conscious thought.

Musical notation is notoriously ambiguous and open to many interpretations. Its crudity is often deplored because it does not allow the composer to lay down precisely his intention and it gives the performer great latitude. But is this ambiguity really an imperfection? If my concept of creativity is correct, it imposes on the composer the wholesome duty of providing in advance for a multitude of not entirely predictable interpretations, all of which should preserve the validity of his work. This conclusion leads us back to the contention that the composer ought not to aim at a precise sound effect, but should leave his work as an ambiguous or-or structure that must be completed by the performer over and over again. Contemporary composers like Stockhausen have been much criticized for their explicit love of indeterminacy. Stockhausen s most notorious work merely supplies the performer with disconnected pieces which he can put together in almost any order he likes. Critics do not credit the composer with a capacity of scanning in advance the astronomic number of permutations of which such ambiguous material is capable.

The undue concern of academic musicians with melodious sonority is matched in painting by an excessive concern for the plastic spatial quality of the painted surface. It has always struck me that even in traditional realistic painting an undue preoccupation with plastic qualities interferes with the proper realization of perspective foreshortenings and so prevents the proper representation of space. The traditional painter has to flatten out reality in his subjective vision and project it onto the flat surface of the canvas. As a reward for his temporary renunciation of plastic vision, his painting in the end will spring into plastic life.

The same conflict between the flat painted surface and the illusion of pictorial space also holds good for contemporary painting. Already the Impressionists had discarded an undue concern with the plastic modelling of space; they were at first only concerned with exploring the texture of single brush strokes. Much later, admiring art critics discovered that by stepping back from the canvas they could obliterate the single brush strokes and fuse them into a new illusion of atmospheric depth in open-air space. The decline into academic Post-Impressionism set in as soon as the painters themselves aimed directly at this new spatial illusion. More recently, abstract painting brought back the essential concern with the flat painted surface as such. But even so a new academic decadence was again able to twist the new sensibilities for abstract values into constructing directly a pictorial space derived solely from abstract elements of form, tone and color. American art schools often base their syllabi on a systematic working-up of these space-making qualities, thereby robbing abstract art of its intuitive vigor. I felt even more dismayed when I tried to trace the origins of this decadence and was referred to the teachings of Hans Hofmann whose own work I had come to admire greatly for its vigorous spontaneity. But, checking more carefully on Hofmann's original opinions, I found that Hofmann himself had insisted that the painter's first duty was toward organizing the flat surface of his canvas; the final effect of a resonating pictorial space came as a by-product of work done well and as a proof that the artist had succeeded in organizing the painted surface.

The resurgent preoccupation of academic painting with modelling the pictorial space in a more deliberate manner is merely another aspect of its general compulsive need for visualizing and controlling the final result with precision, prompted by the rigid intellectualism of our time. However, the good teacher acting intuitively will always invent new exercises that will restrict the range of conscious control and a too precise visualization. Music teaching is here in a privileged position. The need for unfocused polyphonic hearing cancels out the harmful effects of a too precise visualization of the harmonic sound. In order to control the polyphonic structure the student will automatically disperse the narrow focus of normal attention. In painting, a similar automatic dispersal of attention can be the result of counterchange exercises where the simultaneous control of figure and background shapes is necessary.

Other exercises prevent the student from following a straight course to a preconceived solution and force him to handle ambiguous interim results. The British painter Alan Davie asked his students to work on several designs simultaneously. He told them to insert a certain element, for instance a triangle or two parallel lines or a circle, into each design in turn, with the provision that their position and size should vary from one drawing to another. The students did not know what element they were going to insert in the next stage and had to divide their attention among several working processes, much in the manner in which an experienced chess player may play several games simultaneously. Coherent planning becomes impossible and the work is divided into separate interim stages (Fig. 4). Alan Davie used a similar device for breaking down previsualization in a still life class. The students started drawing an ordinary Windsor chair. But before they were able to put down a complete outline, Davie twisted the chair into a new position and asked the student to superimpose the new vista on the first sketch. This he repeated several times. Again the students were prevented from following a straight course to some preconceived target; instead they had to integrate the several disconnected vistas into a coherent pattern. Their reward was a more attractive drawing than they could have produced by a more deliberate design (Fig. 5). Davie's pupils were artistically untrained jewelry apprentices. When they had drawn somewhat painstakingly their first vista, unprepared for the coming disruption, their draughtsmanship was amateurishly stiff and heavy-handed. When they had to give up all planning and conscious responsibility they achieved a lightness of touch and transparency of texture that would have been outside their normal reach. Apparently the frustration of their conscious schemata made available resources not ordinarily at their command.

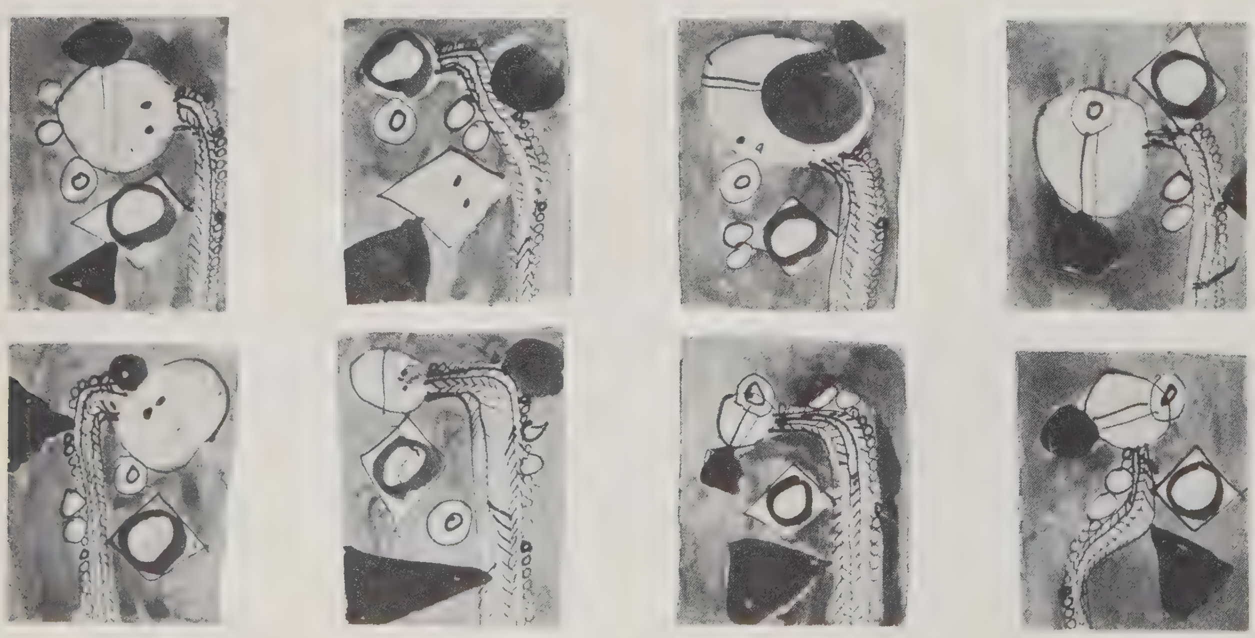


Fig. 5. Superimposition of Contradicting Vistas.
Basic Design Course of Alan Davies,
London Central School of Arts and Crafts.

Fig. 4. Simultaneous Assemblies of Identical Elements.
Basic Design Course of Alan Davies,
London Central School of Arts and Crafts.

There are, of course, innumerable other ways to bring about this frustration of conscious intellectual faculties. All such exercises could be described in terms that I have used for the analysis of the creative imagination, such as a breaking up of the working process into interim stages not directly aiming at a certain final effect, or the dispersal of the normal one-track attention. In figure drawing from life one can interfere with the model or with the student's working method. Harry Thubron of the Leeds College of Art made three models move in independent rhythms. One model had to walk up and down, the other, sitting, merely mimed with his arms, the third moved his whole body. Their concerted movements produced a constantly changing kaleidoscopic pattern. The student would normally have concentrated on one figure after the other, but now while he froze the first figure in a certain attitude he could not yet predict the relationship of that figure to the allover constellation and had to improvise all the way (Fig. 6). The British painter Cecil Collins kept the model still, but disrupted the student's own work. He introduced a kind of gymnastic drill. As he called out his commands the student would have to change his way of holding the brush or of moving his hand, wrist or arm, or change the pressure on his brush, and restrict himself to certain rhythmic movements, rotating or whipping, that somehow might also echo the model's pose. As we would expect, this seemingly arbitrary disruption of the working process improved the liveliness of the draughtsmanship, but far more surprisingly, it also contributed to the naturalistic effect of the drawing in purely traditional terms. In spite of the constant interference on the part of the teacher, the student somehow managed to incorporate all the detail and finesse expected from a traditional life drawing. There would have been little point in reproducing this work here. Apart from its aesthetic and technical excellence no unusual feature betrayed the unusual method by which it was done.

Fig. 6. Figure Drawing after Moving Models.
Course of Harry Thubron, Leeds College of Art.

But perhaps we should not be unduly impressed by the technical competence achieved by the disruption of deliberate planning. It has been my point throughout that professionalism, rightly understood, is not dependent on exclusively conscious planning, but requires a partial lapse of well-defined aims and working methods. In spite of the good work done by individual teachers the true nature of professionalism and technical competence is not officially recognized, least of all in art-educational reforms for the improvement of professional training. The professional use of a medium in any field of design is still kept entirely deliberate and intellectual, safely sealed off from the creative use of the medium that is taught in separate basic-design courses which are considered undisciplined and even playful. As this freer, not entirely deliberate working method is considered irresponsible by the student himself, he does not dare to apply the same freedom of imagination to his more serious professional work. By keeping apart the professional and the creative uses of a medium, the existing dissociation of intellectual and intuitive faculties is only acerbated.

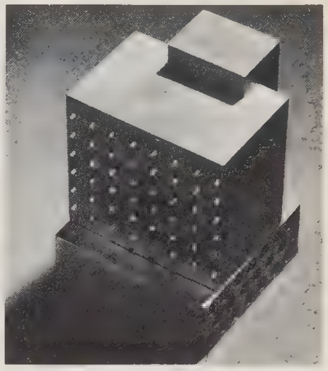


Fig. 7. Set of precisely calibrated weights (1/4, 1/2, 1 pound). Basic Design Course of W. Millar, London Central School of Arts and Crafts.

The badly needed integration between professional and creative training can perhaps be achieved if the methods that at present are confined to basic design are boldly introduced into professional training itself. Steps in this direction are not lacking. For instance, the London School of Arts and Crafts continues the basic design course for industrial designers throughout their professional training, with the object of making basic design studies approximate more and more practical industrial problems (Fig. 7). This means that the basic design teacher, usually a painter or sculptor, has to turn himself into a professional teacher. The logical outcome of this development would be to dispense with the normal professional teachers and their methods altogether, and turn their courses into ancillary disciplines that merely supply technological information for the central basic design course.

I think the present success of the German *Hochschule fuer Gestaltung* has something to do with the fact that the students have to explore functional factors taken from the remotest spheres of human learning, and are presented with data of such complexity that they can only proceed in stages to a solution not yet fully determined. The school's conscious aim, however, seems entirely intellectual and strives toward objective perfection. There is an element of danger in this. Once the stream of new information dries up, the student can easily previsualize his solutions, and the gradual development of stylish mannerisms can no longer be avoided. Even a better psychological understanding of this danger may not be able to prevent the ebbing away of imaginative effort. It seems the fate of all creative spurts in the history of the arts that they end in self-conscious style and mannerism.

GERALD HOLTON

CONVEYING SCIENCE BY VISUAL PRESENTATION

Is the Human Demonstrator Obsolete? Day after day, millions of students in colleges and schools the whole world over watch science instructors perform demonstrations and lecture-table experiments, and use other visual aids, to convey information about science. What good do these demonstrations do? What harm? By what mechanism do they work at all? What else is being conveyed to the student which the instructor does not strive for and which the student does not consciously notice? How may we recognize and understand differences in the style of presentation? Is an actual human being needed as demonstrator, or can his function be fulfilled equally well or better by some technical surrogate (e.g. a filmed or televised image)?

These are some questions with which the present essay will attempt to deal.● But it should be confessed that our interest in understanding the role and function of the scientific demonstration is motivated by a wider problem. For the demonstration in a classroom is merely a special case—in principle, even a particularly well-controllable and testable case—of a more general problem, the problem of how knowledge, technique, and attitude on any subject whatever are conveyed by a human being while another person or group watches his demonstration. This is, after all, one of the most frequent methods of communication, whether between teacher and student, mother and child, or actor and audience. It also operates between the casual observer and the human scene around him, or, in the sense of "Q.E.D.", between two people engaged in work, play, or conversation (recall Galileo's *Discorsi e dimostrazioni matematiche*).

Without attempting a rigorous definition, we can say that the general case of conveying by means of demonstration always involves one person who knows or feels something some others do not yet know or feel, and who wishes to communicate it to others vocally, by gesture or other body motions, and/or by involving symbols or external objects or devices. We live and learn by demonstration. The concept of demonstration as a method of communication in general makes our discussion of the special case of scientific demonstration more widely useful.

If one looks at this subject with fresh eyes, one's first instinct may well be to recommend giving up the actual conduct of scientific demonstrations—and perhaps most lecturing—altogether. By and large, the average demonstration-centered science course has no great reputation for excellence. It is, after all, a fairly recently established practice, and perhaps should be allowed to fade away as if it had been just another fad. Writing of the practice obtaining in 1847 when the Cambridge (Massachusetts) English High School opened, its first headmaster, Elbridge Smith, wrote: "In science, the instruction was wholly by catechism. There were illustrative diagrams in the textbook which might or might not be explained, and might or might not be transferred to the blackboard. . . . Not a single particle of apparatus or a book of reference, except the Bible and possibly a dictionary."[1)]

Today, the argument against the demonstration lecture *in vivo* may be supported by a quantity of telling evidence, not the least being the well-known observation that many of the best scientists have been bad lecturers—some of them embarrassingly so.[2)] There seems to be no reason why a good scientist should be a good lecturer, not to speak of being a good lecture demonstrator. Conversely, some of the best scientists, while students, did not seem to have even attended their science lectures. Although there were excellent teachers at the Polytechnic Institute of Zurich (Hurwitz, Minkowski), Einstein reported in his biographical notes that instead of going to their lectures, "I worked most of the time in the physical laboratory, fascinated by the direct contact with experience."[3)]

Indeed, one suspects that lecture demonstrations—at least in physics, to which the observations of this paper are primarily applicable—offend most perceptive students. They must see through the fundamental misrepresentation in the typical lecture-table "experiment", in which a subtle and beautiful phenomenon is distorted beyond all recognition in order that the ephemeral visual clues can be amplified for the benefit of people seated at a distance. They must be aware of the fact that demonstrations tend to wrench phenomena from their natural context in order to make a "main point" stand out clearly before the average student. And the

●
This paper is based in part on material prepared for the book *Reference Source for Demonstration Experiments in Physics*, edited by Harry F. Meiners for the American Association of Physics Teachers under a grant from the National Science Foundation and published by Ronald Press, New York (1965).

most interested and intuitive students must be very uncomfortable when—to cite an example that is typical—the attention is displaced from the real effect to a substitute or analogue, so that a gross model (e.g. a mechanically agitated tray of steel balls, a device on which the lecturer perhaps has all too clearly invested much time and pride) becomes the means of discussing a basic phenomenon (e.g. Brownian motion)—*without* giving the class a glimpse of the actual case itself.

These three faults of scientific demonstrations—distortion, dissociation, and displacement—will be discussed in some detail below. They are indicators of the gap between physical reality as the working scientist encounters it, and what the instructor in the large lecture room generally exhibits. Now it is precisely this gap which the demonstration, among other teaching tools, is usually supposed to be helping to fill. My feeling is that, on the contrary, most demonstrations tend to increase it.

To symbolize and keep this problem before us, I took a photograph (Fig. 1) in an on-going research laboratory—not prettied up for the photographer, not made into a "demonstration" as so many published pictures of research laboratories are, but having, unretouched, the chaotic visual quality that strikes one on entering most laboratory rooms. The next photograph (Fig. 2) was taken during class in a college science course. The students are facing a lecture table on which there will be some apparatus; but above all they are watching the lecturer-demonstrator. It is a disturbing picture, and I have blotted out the figure of the lecturer in order that the reader can more easily imagine himself in this place. What the successful demonstration experiment should do is to *prevent* the student's eye from coming to rest merely on the lecturer; instead, during the demonstration the student should be able to look through the aperture that the lecturer is creating as access into the world of the laboratory of Fig. 1.

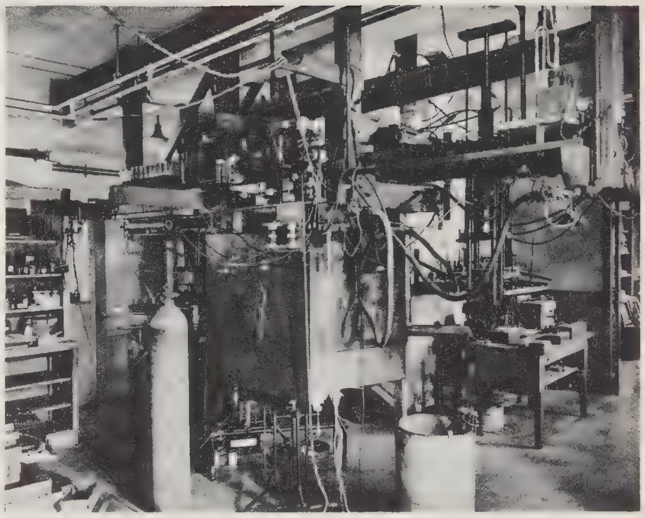


Fig. 1. The World of the Laboratory.
Fig. 2. The Lecturer as Demonstration.

If circumstances in the recent past have weighed against the effectiveness of demonstrations, the immediate future looks even gloomier. One reason for this lies in the nature of the advance of physical science. We have long passed the time when, by means of pulleys, magnets, and electroscopes, one could demonstrate the current state of science, or—a closely related point—when a fundamental discovery was occasionally made in the course of preparing or giving an elementary lecture, as was the case with Kepler, Victor Meyer, Oersted, and Hertz.[4] As the physical events of the laboratory have gone further and further from the "naked eyeball" stage of science, so has, necessarily, the physical reality in the lecture room where science is being taught. In the demonstration of, say, a solid-state or relativistic effect, one requires not only far more sophisticated equipment than we have been using until recently, but far more sophisticated eyes than the student is likely to have, and more sophisticated hands than those of many a lecturer or most demonstration curators. And while the curve plotting the effectiveness of the human lecturer in the science class has been dropping, two other curves have been rising that are equally pertinent. One, of course, is that of the number of students; this increases the size of the class and so affects the visibility and comprehensibility of demonstrations. The other rising curve is that of the availability and variety of educational films and television which offer the demonstrator a chance to escape from his dilemma.

As a result of these trends, we are now moving into the era of the "Automation of Teaching" and the "Technological Classroom". A growing block of opinion concerning the probable future was expressed in the comment of Professor Frederick Mosteller when he discussed his nation-wide, televised "Continental Classroom" course on Probability and Statistics. He remarked: "I see no reason why the lecture portion of most large elementary courses from, say, college sophomores down through the schools could not be handled through TV or film."[5]

Moreover, rising opinions of this sort are not markedly contradicted by the published results of studies on the effectiveness of film and TV demonstrations. The typical finding of such studies seems to be that the performance of students is about the same in the course whether they watched an actual instructor or his two-dimensional image on a screen. For example, D. J. Tendam *et al.*[6] claimed that about 100 demonstrations in a course for physicists and engineers, when shown by film, were found to be "as effective instructionally as the conventional method of presentation". Similarly, in a thorough and searching review, Fletcher G. Watson comments on most of the reports now available: "Apparently they reach a common conclusion: students taught by the vicarious or distant instructors (film, TV) score as well as those taught by an instructor at hand."[7]

It may seem, therefore, that the days of the human instructor, the physically present lecturer in the classroom, are numbered. And in truth, remembering the low value of a good deal of actual lecturing, and comparing it with certain recently prepared films of fine, well-rehearsed and well-equipped physics lectures, one must agree that there is much to be said for hastening this day. Of course, we should replace all bad lecture demonstrations (and lecturers) with good audio-visual surrogates, just as we should let all necessary rote teaching be done by machine. And even in the classes of the good demonstration lecturer, we should let film, closed-circuit TV, etc., be used far more than we have been in the habit of doing.

But we must not get caught up in our usual optimism that any new development which is good should be extended as quickly as possible from horizon to horizon. We are now at a fork in the road, and we have several reasons for thinking carefully before we decide on the path to take. For example, even the average lecturer may not be beyond substantial improvement if we had a better theoretical basis for understanding his function and improving it. This is an important argument in favor of a search for new ideas and speculations on which a theory of this sort may be built.

Also, there are a number of important values which, it appears to me, are conveyed in the interaction between the live lecturer and the student in the same room, particularly through the scientific demonstration, and which *depend* on communication being initiated by an actual person rather than by a surrogate. These values, and the methods of communication, need to be recognized and preserved. A study of such factors, however, will have to go beyond the safe limits of congenial but trite terminology, if it is to lead us to what one might call a nonclassical theory of the function of the lecturer and his visual presentations.

The Classical Theory of the Lecturer. The classical model of lecturer-demonstrator in a science course is well established. The prototype is perhaps described best in a charming booklet gathered from the writings of that master demonstrator, Michael Faraday.[8]

His advice is very much what one would expect. The apparatus should be carefully laid out, and the lecture material in orderly arrangement. The demonstration should have a certain magnitude, appropriate to the point to be made. His actions should be "slow, easy and natural". His discussion should be lucid and to the point. In Faraday's study at the Royal Institution, I am told, the two main objects that greet the visiting lecturer are a huge, beautifully formed quartz crystal and a large container of barnacles; they remind the lecturer to be crystal clear and to stick tenaciously to the subject.[9]

Lecturers, Faraday reminds his readers, should be gentlemen, and the members of the audience should be treated as if they were, too. Faraday repeatedly comes back to the need to "evince a respect for his audience. No accident . . . should disturb his serenity or cause variation in his behavior." And above all, "a lecturer should exert his utmost efforts to gain completely the mind and attention of his audience, and irresistibly make them join in his ideas to the end of the subject".

In short, the classic demonstration lecture is a unidirectional process, executed with an almost Victorian sense of purpose and decorum. It is orderly, tasteful, and well-programmed—and in all these respects, it is replaceable (but for the magnetism of Faraday himself, of which he, of course, does not speak) by a well-made *film*. The key here is the "effort to gain completely the mind and attention of his audience". This tight coupling is indeed exactly what film or TV can achieve better than any other medium.

Recently there has been an extension of the older classical theory, owing to the recognition that the lecture demonstration is only one in a system of connected course elements, one part of a whole spectrum of teaching aids that can be combined or that can replace one another. Film cartridges which the student can use in the library or take to his dormitory to study with the new closed-loop projector are one example of the extension of demonstrations in lectures. Corridor demonstrations in which a lecture-table apparatus is made available later to the student is yet another. Kits with which the student can repeat or go beyond experiments taken up in lecture or laboratory are being introduced also. These and others are healthy developments by which the course becomes less of a hypnotic, one-way, lecture-dominated process. The student is drawn in as something more than a passive consumer.

These changes in the age-old model were partly prompted by the recognition that retention from hearing alone is so poor, that the lecturer's spoken word should be accompanied by other stimuli such as the watching of demonstrations, and that learning is even better if the student participates and manipulates things himself. Moreover, the classical theory has been influenced in the same direction by the increasing stress on concepts such as "creative thinking" and "teamwork" in the classroom—concepts which reflect more of a general sociological than a merely pedagogic trend. For example, in the publication *You and Your Students,* prepared by a faculty committee at M.I.T. in 1950, the first chapter, "Educational Teamwork", is imbued with this spirit. Its second paragraph begins: "The educational process is one of *teamwork* between students and faculty."[10] (Italics in original.)

Natural Complexity vs. Demonstrable Simplicity. To take a rather different view of this problem, a thoroughly *non*classical theory starts from a recognition of what a lecturer *cannot* do well, and what a technical substitute for him can do even less well. If the main role of the demonstration is to help us bring physical, professional reality into the classroom, to show what science deals with, how it is done, by whom, and why, one must explore the extent to which this aim is inherently not fulfillable. One obstacle lies clearly in the fact that the phenomena of current scientific interest are very difficult to transport into the classroom; that, for example, in a laboratory investigation, the sense stimuli that really count are a very small fraction of the total stimuli clamoring for attention.[11]

But the deeper difficulty is that one knows any one thing X in science (as in any other field) in a professional way only if one knows also the connections of X with many other things Y, Z. . . . The facts and experience of science are not atomistically given, but reside in a learned pattern of connections in the subject field. For example, the truth and beauty of the fact that the electron has a constant charge is merely hinted at by what a student can see when he watches a re-enactment of the Millikan oil-drop experiment. The observed motions of the drop take on only a somewhat less limited meaning even when the motions are interpreted by means of a solar system of other ideas that surround this experiment: the measurement and constancy of density of oil; Stokes' law and its range of applicability; the ionization of gases by radiation; the construction of regulated voltage supplies; the statistical treatment of data; and so forth.

And beyond that, if the constancy of the fundamental electronic charge is understood from the oil-drop experiment, it still counts for very little until one can fit it into a larger galaxy of ideas involving quite different experiments, including the constancy of mass transfer in electrolytic dissociation; the constancy of the radius of curvature of cathode rays in magnetic fields (as well as the departure from constancy of the e/m value at high beam speeds); the reappearance of the elementary charge in photoelectric phenomena; the conservation of charge in pair production; etc., etc. And each of these ideas itself is at the center of its own solar system of other conceptions. We now realize that a demonstration at best shows only one point in a constellation, one knot in a net, rather than showing the threads which properly account for this and many other such center points in the whole network of ideas that constitutes a science.

We can here, by an analogy, short-cut a discussion that properly belongs in the philosophy of science. Anyone who has seen the set of tables in the Ishihara Color-Blindness Test remembers that each table consists of a circular field, about four inches in diameter, filled with separate dots of different colors. In the field of such a table, for example, the normal eye may see a digit 9. But the color-blind person will see a 3 or a 7 or no number at all, depending on the form of color blindness. What the normal as well as the abnormal eye sees there is, of course, a learned pattern, just as any "fact" or portion of subject matter is of importance to the physicist because it is perceived by him to fit into a larger learned pattern. It is not the fact, the "isolate" itself, that makes it interesting to him, any more than a single dot on the Ishihara table is of significance. What makes an isolate meaningful is, in the first place, that it is perceived to lie, as it were, along a line that has the form recognized as a 9 in the visual field of the table as a whole; and secondly, that from a different point of view, the *same* isolate can also be regarded as lying along a 3 or a 7.

But precisely here is the difficulty for the student: the number of connections that characterize most isolates of physics is immense; this is, after all, what is meant by saying that physics is a highly and beautifully structured area of knowledge. In order to digest and benefit from the instruction which is offered, the student therefore tends to do what any digestive system does, namely, to first break up the complex structure into less complex parts. Instead of dealing with the digit 9 as a whole, the student concentrates first on some part of the curlicue. And the lecturer, too, helps him to pick out what is "seen" easily, as though it were against a blank background instead of the initially confusing background of other colored dots.

This is where the lecture demonstration enters. The motion of an electric charge in a field cannot, to the uninitiated, be explained or demonstrated by actual examples where this conception counts, either in "real" nature (e.g. motion of protons in the field around the sun) or in the laboratory (e.g. motion of protons in the A. G. synchrotron). Instead, the lecturer might show the experiment of bending the fine beam of electrons in a large, evacuated globe placed in a magnetic field. It is a beautiful "experiment"—for the few students in the front rows who can see something of it—but, like most lecture demonstrations, it is of necessity and almost by definition a carefully adjusted, abstracted, simplified, homogenized, "dry-cleaned" case, far removed from the physical situations in which charged particles traverse fields either in out-of-doors nature or in the contemporary research laboratory. It is here as if all the blue, red, yellow, purple, etc. dots in the Ishihara color plate had been removed so as to let a continuous line of green dots stand out against a blank background, and then much of the digit 9 itself had also been cut off to focus attention on only part of it. The trouble is, of course, that this part of the original pattern by itself is far removed from the interesting information; the original, complex figure 9 that can also be a 3 or a 7 has disappeared, and in its place there stands something that might be mistaken for a zero.

Experiential Reality and Didactic Reality. We have noted that demonstrations are necessarily simplifications of a natural complexity; they are almost always distortions of the physical situations with which the physicist works. We may thus, for the purposes of this essay, distinguish between two kinds of "reality". One can be called *experiential* reality, namely, that of phenomena and events in their full context, embedded in rich complexity, burdened with secondary and tertiary "side" effects that are not suppressed and forgotten—the 9 against the full-spectrum color background that also implies the 3 and the 7; the electron that is not merely a thermionic emission hurled into a homogeneous magnetic field but that also may be a net charge on an oil drop, or a photoelectron, or a decay product in a bubble chamber; the force on a moving object not only due to gravity, but also due to the resultant of gravitational and electrostatic forces as well as air currents.

For the purposes of evaluating the usefulness of pedagogic techniques, we shall introduce here the heuristic notion of "levels of reality", and identify the experiential reality of the research laboratory as a "first level" or "first order" of reality. Consider that below it, at the second level, there lies the arranged, *didactic* reality of the lecture room. At its best, this can make a wonderful show and teach a great deal—as, for example, the torsion-wave machine made of delicately balanced bars strung on a long, stiff strip of metal. But these are exceptions. After a steady diet of didactic demonstrations, a musty, stale atmosphere settles over the lecture, as on almost everything else done in the course: on the student-proof laboratory setup, on the aged exhibit, on the obedient turn performed by a captive and tamed phenomenon—the ancient finger exercise instead of actual music.

Second-level or second-order reality also pervades the science museum, as has been well described by A. E. Parr, Senior Scientist at the American Museum of Natural History. "As each specimen adds to the awareness that everything to be seen was made for exhibition only, and has never existed for any other reason or purpose, a certain degree of indifference becomes unavoidable in even the keenest enthusiast about the subject matter illustrated by the display. . . Even the least sensitive may begin to sense, however vaguely, that science is actually not inviting him in, but keeping him out with carefully planned and cleverly executed substitutes for the 'real thing', deemed more appropriate for a layman's unsophisticated capacity for appreciation."[12)]

What I am stressing here is not an argument against good demonstrations on the level of didactic reality, but rather an argument for supplementing these by introducing first-order reality far more frequently than I believe is generally done. *Even at the risk* of occasionally bringing into the classroom a sample of reality on too high and too complex a level for the student's full comprehension, I would urge three remedies for a class surfeited with didactic reality. One is that the student should see (and preferably participate in) experiments that are not precleaned for him, where the surfaces are not smoothed and planed, the connections not supplied in just the right number, and all stray fields not shielded against.

Second, in this light one sees the increased importance of visits to on-going research laboratories. Every large installation on or near the college campus, such as a new accelerator, should really be obliged to have a well-designed area in which students can come to visit and watch, even if it has to be at a distance and from a glass enclosure. (Incidentally, how better can one fully defend the placement of these installations into an educational institution than by opening such an opportunity?)

But as important, even essential, as such visiting areas and visitors' days are, I have my eye also on the need of taking the class into not one, but many functioning laboratory rooms. Thus, following the lecture discussion of the motion of charges in fields, the conference or recitation section might be held in an instructor's molecular beam laboratory, even if it is crowded and the apparatus can be shown only briefly to illustrate some of the course discussion. We must experiment more with the occasional transfer of the class from the antiseptic section room into those messy places where what one sees was not made merely to be shown, but where experiential reality teems and squirms in its glorious and maddening abundance.

Third, I would urge bringing into the regular classroom as often as possible equipment and pieces that function in commercial technical apparatus or, better still, that at one time or another have fulfilled some purpose in actual research. We may perhaps be allowed to call them *relics*. We do not mean to turn our backs on well-designed, didactic exhibits—indeed, one wishes more attention were paid by our manufacturers of educational equipment to the visibility of scales, the cleanness of design, the ingenuity of pedagogic aids, etc. And yet, occasionally there must enter into the science classroom a piece of equipment that has an atmosphere of authenticity. Considering all the school years in which the student sees mostly things which were made explicitly for didactic purposes, he is surely entitled to sense what lies at the end of all this pedagogic experience.

Hence I strongly urge a reconsideration before outdated research equipment is relegated to the attic. Even a single component, say, a piezo-electric crystal or a grating, is better shown to the learner *in situ* than torn from its chassis or preserved in its wrapping. The authentic equipment can convey a great deal of information over and above the scientific one. That, too, as I shall have occasion to stress below, is of great importance; for example, it reminds the student in a meaningful way of what the educational institution is all about and what else his instructors are doing besides teaching. Therefore, perhaps a dozen times a year a relic that was involved in respectable research should be introduced into the classroom, if only briefly.[13]

I can attest to the fact that the introduction of local relics—and, of course, of *international* relics, if one has them!—can have an electrifying effect upon the class. Thus, our classes are always intrigued by the simplicity of the shop-made equipment with which E. M. Purcell, for some early research, obtained a narrow beam of beta rays; we now use the source in lectures to demonstrate deflection by means of magnetic fields. Or, at another time, we pass around the class a small varnished cube of uranium oxide which E. C. Kemble brought back from the "Alsos" mission to Germany toward the end of World War II. The student can at last touch something; can feel with initial surprise how heavy the cube is; can quickly digest the fact that a long half-life corresponds to a relatively low disintegration rate; and so forth.

Even a well-chosen piece that was part of a more routine investigation has its uses. It can, for example, convey the same respect that any example of good craftsmanship evokes. And at any rate, these exhibits of nonpedagogic items are necessary tokens of first-order reality—necessary for many reasons, but none more important than the easily neglected fact that the student, unlike the instructor, usually cannot even know that there *are* different levels of experience. Hence the instructor must explain the difference by means of examples.

Depiction and Lower Levels of Reality. In the last section I have conspicuously left out what is perhaps the easiest way of representing physical reality in the classroom—namely, by filming a sequence in an actual laboratory, or by closed-circuit TV from a laboratory, or by the use of slides, photographs, etc. All these are, of course, immensely important parts of the spectrum of lecture aids. Most new lecture rooms should certainly be built with TV facilities and coaxial cables going to the laboratory buildings, so that closed-circuit TV may routinely be brought into the lecture. Moreover, every college that can afford it should begin to have someone experiment with a movie camera, to bring back films made in local laboratories to supplement useful films which are now becoming more available commercially. Indeed, all such science lecture aids must become as natural and ubiquitous as are records, tapes, and sound-reproduction equipment in the well-run music course.

But it is important to realize that with films, TV, slides, and photographs, we are going down to a third level of reality. We are now speaking of *depiction* rather than watching the events themselves. Furthermore, these devices for depiction are generally used for depicting on the two-dimensional screen not even what has happened in first-order reality, in the physical situation of the laboratory or in nature, but what has happened in a didactic arrangement. Even at their characteristic best, we are dealing here with, for example, movies of ripples spreading through a water-wave tank, a device invented by Thomas Young for his lectures to laymen at the Royal Institution, and since that day a century and a half ago, virtually never used for anything but pedagogic purposes. Such films are therefore in a sense representations of representations. This does not derogate these useful teaching aids; but the realization on which level these media operate will show us that our teaching aids can take us away from their avowed aim, which was to help close the gap between the classroom on one hand, and physical reality experienced and understood in its full context on the other. We shall return to this topic later.

At an order below depiction, we come to a level of classroom reality in which we find *animation* and *models*. Here the avowed contact with first-order physical reality has been almost completely broken, and the device shown functions analogically. One is looking at a translation into wood and metal and paint, at an analogon, rather than at either the phenomenon itself or a depiction of it. These devices are often very useful, as, for example, the Soviet-built machine for illustrating wave motion by the motion of little white balls on rods that are controlled by strings, or the series of liquid-supplied, interconnected vessels which illustrates how members of a radioactive series reach their equilibrium level.[14] The characteristic which such fourth-level devices share is that the physical forces and laws by which they actually work are not the same as those that are being "demonstrated". Therefore, a sharp discontinuity in meaning and authenticity exists between this and the higher levels of reality. Watching a movie taken of the Brownian motion in a colloidal suspension is, in terms of perceived dramatic impact, less impressive than seeing Brownian motion itself through the microscope's eyepiece; but a *model* for this phenomenon, using agitated metal spheres, is qualitatively far below both of them.

Moving on to the next lower order of reality, we come to the kind of teaching aids that form the bulk of demonstration lectures: graphs and slides, writing and talk. They may be termed *condensed coding*. Thus, a slide made by time exposure of a particle in Brownian motion is a shorthand device that eliminates the time dimension by representing the whole sequence of happenings at one glance. This is, of course, even more true of a slide or sketch of a zigzag line drawn between points corresponding to a sequence of observed positions of a particle in Brownian motion; similarly for slides or blackboard drawings of lines representing ripples setting up an interference pattern, and for many other such cases.

These projections, graphs, written equations or phrases, and indeed, the lecture talk itself, all convey information by indirect means (rather than, say, by exemplification) in the form of condensed coding concerning possible happenings. It is similar to the projection of a musical score instead of the performance of the piece itself. The analogy I wish to stress here is that to the skilled musician or musicologist, scanning the score is closely parallel to the experience of an actual musical performance. The same is true for the choreographer reading a piece in the condensed abstraction of Laban's dance notation; and in a sense the same applies when one reads someone else's skillfully presented paper on results in one's own special field of work in the *Physical Review*.

But this argument cannot be extended to the student. The lecturer might say, "This is how waves interfere", when he projects two superposed transparencies that carry on them a set of concentric black semicircles; but the student, who is unable to make the shortcut from coding to phenomenon with the same intuitive facility, sees first of all only a multiplicity of more or less well-focused lines on the screen. The gap is not bridged either by overlooking it, or by failing to help the student to make the transition from this (fifth) level to the first.

There are even more remote degrees of abstraction below those cited so far. At the sixth level is thinking about scientific problems without ordinary language, in the language of direct abstraction of which Einstein spoke in his reply to Jacques Hadamard.[15] At this level, on which perhaps thinking of any originality in all scientific fields proceeds much of the time, the pictures, words, graphs, and equations have disappeared. And still below this, at the seventh level is the direct apperception of a complex situation in its entirety, including the type of circumstance where a solution suddenly rises into the consciousness, to the surprise of the scientist who has not been aware of thinking of the problem. (The prototype example is that related by Henri Poincaré when the theory of Fuchsian functions occurred to him on boarding a bus at Coutances; or Kekulé's sudden vision of the chain formation of carbon atoms during a bus ride in London.)

Table I: Levels of Reality in Scientific Presentations

1 Experiential reality.

2 Didactic reality.

3 Depiction of phenomena (film, TV).

4 Analogon (model, animation).

5 Condensed coding (graphs, equations, words).

6 Metasymbolic abstraction.

7 Unconscious or intuitive apperception.

Table I lists the order of "reality", from experiential and didactic down to abstract and unconscious. Two points of importance may be made here about this sequence. One is that between the first and the last, going from top to bottom, there are significant over-all differences in the natural time scale associated with perception at each level. Thus the action and phenomena themselves, at the first level, can have a natural time scale that may be long—for example, given by the speed of waves across open water or by the rate at which a quantity of radium is transformed into radon and other daughter products. This time scale may be preserved substantially unchanged at the second level, i.e., when the same phenomenon is "prepared" for didactic exhibition, though occasionally the time scale may be somewhat extended or condensed (such as by preparing a smooth inclined plane to reduce friction by which a sliding object will cover the distance faster than it generally would *in natura*).

The depiction at the third level, particularly under the pressures of classroom time, can result again in a more condensed time scale (although for certain didactic purposes a much-too-fast phenomenon may be rendered slower by slow-motion photography, etc.). The operation of models and animation, at the fourth level, may also have its own time scale, but often they are used to condense the natural time lapse in the phenomenon they represent (as in the case of orreries, or the brief token repetition of lengthy experiments such as Joule's). At the fifth level, condensed coding in graphs, slides, and symbols serves again for the most part to reduce the time scale. The rapidity of thinking in the abstract (sixth level) seems to be much greater than conscious logical thinking in symbols. And at the bottom of the list, unconscious thinking appears to be perception in dramatic wholeness rather than in a sequence of actions, and so may not be an activity extended in time, but the momentary comprehension of a complex situation in entirety. (One is reminded of the great rapidity with which, it is said, one dreams a sequence of events that on later, conscious recall appears to have taken a long time.)

With obvious exceptions, there is on the whole, therefore, a tendency for a time scale of events to be reduced as they go from first-order reality to lower levels of representation. And this, clearly, is one of the advantages of the process of abstraction itself from the first to lower levels. Now this brings us to the second point: a well-trained physicist has long ago learned to "see through", or tunnel rapidly from the first order of reality to lower levels, e.g. to the fifth, sixth, and seventh levels.[16)] It is, after all, on the lowest levels that he "understands" his subject matter and "knows" the many implicit connections of the isolate which he is discussing, rather than on the higher levels that take so much time, as in presenting a demonstration. Understanding scientific materials, and perhaps understanding anything, depends on a cybernetic act by which one leaves the first level, the realm of the perceived phenomenon that poses the problem initially, and transfers, as rapidly as possible, the internal dialogue to the lowest levels; the decisions reached there allow one then to go back to the field of phenomena itself—to look, so to speak, for the heretofore unrecognized 7 that stands behind the initially obvious 9. It is in this manner that we discover and learn, that we decide what it is in the chaos of events which ought to be looked at and called first-order reality, that we select what is worthy of our study and of communication to students.

It follows from this, perhaps surprisingly, that the use of demonstrations may not always be an asset. Despite the almost universal use of demonstration lectures involving visual aids and other teaching aids on the second, third, and fourth levels, I cannot prove that they are in most cases necessarily more effective than some other teaching process. One can, in fact, conceive of counterarguments—for example, that one's appreciation and skill at the quick "tunneling" process from the uppermost to the lowest levels are not advanced but retarded by stressing intermediate presentations. One is reminded of Lagrange's decision to keep diagrams out of the *Mécanique Analytique,* as if he had feared they would make the argument too concrete and specific. Though I feel (or hope) that this is not a likely hypothesis, I see here again the urgency of having more studies and thoughtful experiments on how and to what extent visual presentations aid in the learning process. One cannot overlook an opinion that has been advanced by a number of thoughtful people, such as Dr. Edwin H. Land, to the effect that at least for certain students, creative learning may not occur nearly so well in a classroom situation as when the student is from the beginning put into the laboratory and is allowed to work on problems whose natural complexity is not hidden by a didactic, prior separation of the elements.

Further Pedagogic Consequences of Recognizing Orders of Reality. A number of further consequences follow from the recognition that in the science classroom, the "reality" of the subject matter can be presented on any one of several levels.

(*a*) It seems plausible that the closer the demonstration is to the first level—the experiential level of reality which is, after all, the subject of actual study by the working physicist, the source of his understanding and his puzzles—the greater is the pedagogic effectiveness of the demonstration, as long as technical obstacles of size, visibility, etc. do not negate the value of the demonstration in the first place. To be sure, plausibility is not a guarantee that this theorem is generally true, and this, too, is an inviting area for research.

To translate this postulate into practice: On introducing the concepts of interference, for example, one should rely not on diagrams or models or films but on exhibitions of actual, first-order cases: exploring an interference pattern by means of a suitable probe sweeping in front of a mounted loudspeaker or around a transmitting antenna; letting each student see the interference fringes when light passes through a thin slit; showing interference patterns from thin films, etc.

Later in the same set of lectures there will of course also be opportunity to discuss interference at each of the other levels: on the didactic-reality level, one may be demonstrating the water-wave tank, or the demonstration equipment for interference of centimeter waves radiated from one or two dipoles; and so forth. On the third level may be used (depiction) films of both natural and pedagogic events that illustrate interference, e.g. the water-wave tank films. On the fourth level (analogon and model), interference can be shown by means of machines in which waves are represented by bent wires, etc. On the fifth level, diagrams, graphs, etc. are available on screen or blackboard. This whole spectrum of aids is represented in Table II. But the theorem stated at the outset would ask us to stress, emphasize, favor, lavish particular care on, begin with, and repeatedly return to, examples at the highest levels.

Table II: Presentation of Interference on Different Levels of Reality

Level of Reality	*Example of Demonstration*
1	Exploration of interference pattern set up by industrial or research device.
2	Operation of water-wave tank or other pedagogic device.
3	Film or TV image.
4	Simulation of interference phenomena by an analogue device.
5	Drawing, projected or on blackboard.

In the absence of data, one can only speculate on the question of whether, for pedagogic purposes, a natural sequence exists from the first level down. The natural sequence appears to me to be generally from the top level to the lower ones. This is probably contrary to the order in most lectures today (i.e. one tends to start with a quickly drawn sketch on the blackboard or a simple model). Yet the vertical progression from observable raw phenomena to abstraction and explication is indicated as usually preferable by the theory developed above, most of all by our desire to anchor the concepts being developed as closely to their complex natural habitat as possible. If this order is adopted, one may well return at the end of the sequence to repeat in greater detail the first, conceptually richest type of higher-order demonstration.

(*b*) The lecturer should make clear to himself and the class on what level a demonstration is presented. A student is generally not so agile that he can distinguish quickly and clearly between, say, the analogon and the reality it tries to represent. The difference should be explicitly made; it can be spelled out briefly enough. Similarly, some explanation is required if the lecturer in a demonstration course does not show a major phenomenon on the first or even the second and third levels. At the very least, the lecturer himself should re-examine why, on an important topic, he is not using high-order demonstrations.

The list of alibis for failing to use higher-level demonstrations runs somewhat as follows: too expensive (but most lecturers spend too little money on new and improved apparatus); too time-consuming to set up (but one can hire extra help, even an undergraduate, who would gain a great deal from the experience); too dim to be seen by the whole class (e.g. projection of slit interference experiment; but students can be given, or can make, slits on film for individual viewing); too fast (but much can be done with a good Cathode Ray Oscilloscope or a Polaroid camera and a strobe light); too slow; too small; too big; too dangerous; too delicate; and so forth.

(*c*) If we take the primacy of upper-level presentations seriously in planning demonstrations, we should consider whether the same need does not also exist with respect to the problems that are assigned to a class. At least occasionally experiential reality in its greater complexity and richer context should enter even these problems: instead of giving digested, reduced data of an idealized *Gedanken* experiment, we should give the raw record of an actual (even if didactic) run. For example, give not just the data for distance and time, but at least the stroboscopic photograph depicting the motion; and better still, take the photograph as part of a lecture demonstration in the first place; and even better, let the student take it himself as part of his laboratory activity.

(*d*) Depictions and analogies are translations. Therefore, one must be watchful for incomplete rendition, mistranslation, and unintended meanings, as in all other such cases. One must remember that all translated messages tend to suffer from nonlinearity, limitation of band width, and noise. In addition, the different culture context of the recipient can produce a profoundly different response to the translated message.

In terms of our discussion, for example, a mechanical analogon of wave motion will leave most students with the implicit feeling that there is no difference between small and large amplitude phenomena; this error is less likely if they can watch ripples and waves directly. A model, a film, a slide, a projection, a blackboard drawing invariably changes the setting of the phenomenon. An obvious example of this effect is the loss of a natural size scale. In most such cases the student does not know whether he is looking through a microscope or a telescope. I recall, for example, the talk announcing the first successful production of quartz crystals grown in autoclaves by a commercial company. A slide of a beautiful crystal was projected, an impressive photograph filling the large screen and spilling over on the wall to each side. Only in the question period did it turn out that the length of the crystal was a few millimeters.

(*e*) The uses of depiction in particular need to be greatly improved. It is, for example, a veritable scandal that classes still do not have adequate means for depiction in three dimensions by projection, or by inexpensive individual viewers with adequate optics. I understand that it would take very little in terms of technical development to produce the kind of screen by which three-dimensional projections could be viewed by large classes. We are probably dealing here again with the bottleneck that has deprived us for so long of vigorous development of lecture demonstrations—namely, the tariff-protected apparatus industry that is supposed to specifically serve the educator.

We may have to take our cue from the way that the much-needed overhead ("Vu-graph") projector became available recently—not through the efforts of the two or three companies who divide among themselves almost the whole educational market, nor, for that matter, through the large specialized optical companies, but through a small independent company that had not previously been prominent in developing instructional devices. The same applies to the 8mm. continuous-loop films for the splendid Technicolor Company projector. Here, too, we might have expected help from established educational suppliers or the large makers of projectors; but to this day, they have not managed to give us even a really good, ordinary, simple film projector for classroom use. The same principle lies behind the recent entry of Macalaster Company into the production and marketing of ingenious, inexpensive laboratory apparatus; the production by Ealing Company of kits based on apparatus drawings gathered by the American Institute of Physics and of 3-D slides of nuclear events in bubble chambers; and the breaking by the Physical Science Study Committee and Modern Learning Aids of the strangle hold of mediocre educational films from the major producers. Apparently the science instructors themselves will have to continue to do research on educational devices and will have to give encouragement to companies other than those few large ones who so far have been identified with the educational field.

(*f*) When all is said and done, there are some uses of lecture demonstrations which will not fit well into any scheme, but which, nevertheless, recommend themselves for reasons of their own. The occasion arises for some demonstration simply because it is beautiful. The changing interference patterns of light in Tchelitchev colors, reflected from the thin film of a soap bubble; or the tracks in a continuous cloud chamber; or even just the back-and-forth flow of energy in coupled pendula—such demonstrations deservedly get more time than may be strictly necessary on pedagogic grounds alone. There must be time enough to gaze at some of the visually fascinating or aesthetically satisfying things of science for their own sake.

Another defensible aim is to convey a problem, a paradox, a puzzle. It is particularly appropriate if for this purpose lecture demonstrations are chosen which follow more or less the original experiment in which that problem or puzzle arose (e.g. the Oersted experiment, the photoelectric effect for polished metal surface, C. D. Anderson's photograph of positron track). Then too, a well-placed experiment may help to break the dullness of a classroom routine, refresh the attention of the student, insert some humor. One remembers Leonardo da Vinci's warning that one should not judge art when tired; nor should science be so judged. In this category of stimulating occasions belong such demonstrations as the "rocket car", a CO_2 fire extinguisher mounted on a small steerable, three-wheeled carriage, which demonstrates the action-reaction principle while the lecturer, seated on the car, is jet-propelled out of the room.

But I must confess my prejudice against such spectacular or audience-participation type demonstrations, except on very rare occasions. Otherwise, we train the student to expect a show, to have habitually the reaction with which Diaghilev is said to have greeted Jean Cocteau when they were first introduced. Diaghilev looked at the young man, of whom he had heard remarkable things, and said only: "Astonish me."

The Function of Human Presence. In view of the distortion involved in didactic presentations, and even more in analogons, graphs, and similar translations, the question arises why these lower-level demonstrations are in fact pedagogically as useful as they often are. Why is it that we can do so much with models and drawings when the physical reality we are discussing with these aids is kept so far away? The large part of the answer, I believe, lies in the fact that these devices are mediated by an actual human being: the lecturer in front of the student. We must therefore now try to clarify the function of the live lecturer. This really depends, to put it simply, on knowing what the important differences are between a human being and his surrogate (e.g. a projected image of him, his printed or otherwise programmed instructions, etc.).

The success of devices at lower levels of reality is puzzling in the same way as the early success of Shakespeare's profound and subtle plays is puzzling; for the original audience—largely the illiterate laborers in the pit—could not understand the classical allusions or complex historic references, and yet they felt the power and meaning of the play coming across the footlights. It was to some extent the setting of the drama which helped here, the visual experience, the movement, light, and color of costumes, etc. But there was something more, and this was added by the actors, the human beings on the stage. The question there, as here, concerns this efficacy of the presence of a human being in conveying a message of great complexity.

We can begin to deal with this difficult and ambitious question if we think first of some of our most successful science demonstrations. Measured by any criterion, two of the most impressive demonstrations I have seen or done are quite humble.

The first is an illustration of the law of conservation of energy. The lecturer has previously fastened a long pendulum suspension to the ceiling of the room, the pendulum bob being a large, cannon-ball-sized iron sphere. He draws the bob far to one side of the room, puts his head immediately adjacent to it, steadies himself with one hand against some support, and releases the ball. Keeping his eyes fixed on the audience, he explains that he is willing to risk his head that the law of the conservation of energy applies, and briefly reminds the class how it is involved in this case. Meanwhile, the ball has been swinging far out, and is returning toward his head threateningly. (Indeed, if the lecturer steals a glance at the pendulum now, he will involuntarily recoil, and look foolish.) But—seemingly at the last moment—the ball slows down sharply as it regains its original level, and momentarily barely touches the head, or at least is again close enough so that it seems to. The law of the conservation of energy has given a correct prediction. The lecturer survives.

The second demonstration is also well known, and concerns the law of conservation of angular momentum. The lecturer, initially motionless, stands on a small platform that can rotate with little friction in the horizontal plane; he sets a weighted bicycle wheel into rotation with one hand, while holding it up with the other in a horizontal plane above his head by means of a rod fastened through the axis. This act causes the lecturer's platform and own body to rotate in the direction opposite to that of the wheel. Now he turns the axis of the wheel around 180°—and this, strangely, also changes the direction of his own rotation. While he inverts the wheel, he appears to be struggling with something. He may even look as if in danger of falling off. But he steadies himself, and though his dignity may be somewhat impaired by his gyrations, he manages to stay on his spinning platform.

There are two significant aspects of these demonstrations. First, they are not depictions or models, but actual happenings—if not on the first level, at least on the level of didactic reality. They were set up especially for the purpose of show, but they involve pendula and wheels, and are tied fairly closely to events that are taking place all the time outside the classroom, as the lecturer makes clear.

This immediacy is, however, only one aspect of the power of these demonstrations; more significant is the second aspect. The lecturer, by his action right there in front of the class, can show vividly that the pedagogic process and the subject which he is discussing are important. He is willing to risk his head. He risks falling off the platform. He certainly is also putting his dignity in danger. Indeed, he has no more effective means for proving his personal interest and involvement to the class—or to himself, if occasionally he experiences stage fright.[17]

And this is true not only of these two demonstrations, but in a sense of all demonstrations, with the significant exception of one type, to be noted in a moment. I recall that during a lecture in which I discussed rotating coordinate systems, I brought in an umbrella and used it to indicate the possible directions of rotation of a reference plane about its reference axes. After the lecture, a Japanese physicist who happened to be visiting in the lecture came to me, strangely amazed by this performance. He felt moved to thank me for going to such extremes in my solicitousness to make my class understand a point. It turned out that for a Japanese professor, opening an umbrella inside his classroom would be considered a demeaning (i.e. dignity-risking) act.

But even in our own cultural context, the lecturer's engagement in the manipulation of apparatus right here and now has some of this quality of taking risks, particularly if it involves his own body—risks, it should be noted, that need not come to the student's conscious attention to be perceived by him. And it is not only my dignity and my physical safety which I am seen to be willing to endanger or suspend. In executing a demonstration myself, I am also making another personal commitment which no surrogate can make. Of course I do not have to stage a show that keeps the class in suspense as to whether I shall break a leg (or worse: though I have not been able to substantiate them, I have heard of cases in which lecturers died in accidents during their lecture demonstrations). There is also the continuing, implicit possibility that I may somehow cause damage to expensive equipment and in other ways may be led or forced by the apparatus to do outrageous things. There is in every spectator somewhere a savage who tests, by watching the manipulations on the stage, the swinging trapeze or the musical instrument, whether this is good magic or bad, whether the performer does or does not have mastery over it, whether the gods are favorably inclined or not.

Personal commitment, shown by an implicit willingness to take certain risks—this is the element in the participation of a human being which is completely lacking in the operation of the surrogate: it is the precious indicator of the major difference between the two, which is, to put it simply, that the latter is completely programmed whereas the former is largely not. Therefore, nothing of the element of the unexpected or the personal risk remains in educational films. It is lost in the process of "canning". One recalls the boy in the cartoon strip "Peanuts" who is standing on his skis at the top of a small hill, looking anxiously down. At great length, he says to himself: "I wish this were on film; then I would know how it comes out."

The lecturer's freedom from both the subjugation and the safety of tight programming, which is implied in his readiness to risk the unexpected, is kept before the class through the unavoidable occasional malfunctioning of an experiment. His perceived readiness to risk the dangerous is enhanced for most students by the primal fear associated all too closely with scientific apparatus, as shown, for example, in Margaret Mead and Rhoda Métraux's survey for the American Association for the Advancement of Science.[18] These two factors do not, of course, explain fully the human lecturer's attention-sustaining power, but they are significant components. Prepared depiction (film, nonlive TV) are fundamentally neutral with respect to risk and commitment. A class that relies largely or entirely on prepared depiction, or that avoids live demonstrations for other reasons, lacks what I regaıd as an essential ingredient in communicating to the student the importance of the subject. While the lecturer who refuses to use good films from time to time is unnecessarily turning his back on a major teaching aid, the class that is in its entirety or in its demonstrations conducted by depiction only is, in my view, empty at its center.[19]

Risk is only an extreme element among those that make the person effective *in vivo*. Simple willingness to spend time, to argue, to guide the student "as if by the hand", are other elements. The physicist John Wheeler of Princeton University has recently written that in the development of major ideas in physics, an essential element has been the live encounter between student and teacher, for this is the condition for most effectively passing on from one person to another "the quality of caring deeply" for a subject.[20] He holds that in "personal contacts", i.e. actual physical proximity of teacher and student, a link in a "charismatic chain" may be established, and he reminds us that in the apostolic succession the charismatic chain was established also by personal contact, symbolized by the laying on of hands. While his speculation may not at first be appealing to the average physicist, it is a useful image, and an intriguing reminder that the quality of caring deeply may not be effectively transmittible by a surrogate.

If the irreplaceability of the actual person is recognized, the irreplaceability of film or television as an occasional aid must also be accepted. Leaving aside the element of engagement, as covered by the actual lecturer's day-to-day presence, the supplementary film of a superb lecturer, and particularly of a demonstration or manipulation, can be better in a dozen ways than the same activity carried on by a less skilled or less knowledgeable individual. There is no doubt that within the indicated limits, these teaching aids are to be much prized and much further developed. I suspect that their usefulness can be increased at a fundamental level. Thus it is obvious that these surrogates in their present form introduce certain marginal distortions and falsifications whose role in the learning process may be more significant than has been realized so far. For example, part of the perceived reality of a person is surely apparent size, perspective, and color balance. A two-dimensional image distorts these in many ways.[21] Then, too, in projection and screening equipment, the point from which the voice or other sounds originate is misplaced with respect to the visualized part of the body or apparatus—not to speak of distortions of the natural frequency spectrum, of balance of overtones, of amplitude, etc. And when the lecturer moves and turns as he speaks, his voice *in vivo* is perceived very differently from the voice reproduced over the loudspeaker.

Now it is obvious that such defects are not major, and by themselves they do not speak against the use of good visual aids. But studies of these problems of verisimilitude are needed, and could well yield substantial improvements. Moreover, a proper recognition of differences in the areas of maximum effectiveness of live *vs.* non-live performance can well give rise to new techniques of visual communication. For example, I suspect that in a carefully chosen *mixture*, depiction and live presentation can complement and enhance each other with startling effect. This is said to have been true for the performances of the *Laterna Magika* troupe from Czechoslovakia; and I have seen it splendidly confirmed at IBM's exhibit at the 1964 New York World's Fair.

Two Styles of Lecturers. If a theory of the function of the lecturer is to be of use, it should be able to illuminate for us the variety of styles of lecturers. And we can begin to see here the basic difference between two of the many types. Thus, to use the terminology Dr. A. Petrie has developed for a rather different purpose, we may discern "Augmenters" and "Reducers". The Augmenter is the lecturer who enhances or even exaggerates demonstrations in which the unexpected and the threat to body or dignity are significant elements. He participates vigorously, mounts the lecture table or a ladder, and stresses large-scale equipment, smoke, noise, explosions, etc.; he invites the audience to participate physically, and keeps the class quite often in mild uproar. His method of expressing his concern usually causes him to be well liked and sometimes also slightly ridiculed—a significant combination. Fig. 3 caricatures this type.

Fig. 3. The Lecturer: "Augmenter".
(Contemporary caricature of experimental lecturer at the Royal Institution; Humphry Davy agitates the bellows and Count Rumford stands at the far right. Reproduced by courtesy of Professor S. C. Brown.)

The Reducer, on the other hand, is likely to remove himself as much as possible from the scene as an active participant in the demonstration. He tends to read his lecture from prepared notes, and to use the services of a curator to help him with the demonstrations, as was the case until not long ago in continental universities. He stands distant both from the equipment and from the class; his lecture is carefully planned to minimize the possibility of unforeseen events; his demonstrations are economical and to the point, dry, and perhaps even dull. Whereas the Augmenter likes to be "hot" and seems to invite risks, the Reducer likes to be "cool" and avoids them. If he does not have much natural dignity or is worried about attacks on it, he may be protecting himself by being terribly pompous. While the Augmenter cares so obviously that he makes one sometimes laugh, the Reducer withdraws evidences of his personal involvement so that he makes one sometimes wonder if he cares at all. Fig. 4 shows this age-old type of lecturer.

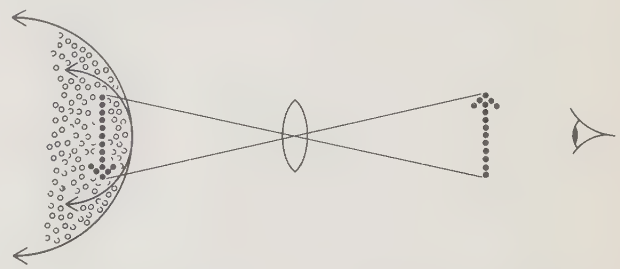
Fig. 4. The Lecturer: "Reducer".
He recites or reads from Galen, and neither participates in the demonstration nor is attended to by his students. From Johannes Kethan, *Fasciculo di Medicina,* 1493.)

Lecturer, Audience, and Subject as Coupled System. The engagement of the lecturer owing to his physical participation during the demonstration, and the engagement of the audience owing to its only lightly slumbering awareness of the possibility that surprising and risky events may happen—these are by no means the only links by which the lecturer, the audience, and the subject material under discussion are coupled. One such link, probably unique to the science lecture, is that through the manipulation of apparatus or other demonstrations before the audience there appears to be introduced an element external to both the lecturer and the audience: the material equipment itself.

The external object serves to focus the attention of both lecturer and audience upon it. Everyone in the room, even the lecturer himself, watches the apparatus, contemplates its function, thinks further about the principles it embodies. In a course outside the natural sciences, namely, in the social or humanistic studies or the arts, the main subject matter to which the lecturer and students together explicitly attend is at bottom always man himself—his condition or relations, his potential, habits, or life cycle, his tastes or artifacts, etc. But in the science class, the subject to which all the persons in the room attend is, as one usually puts it, the functioning of "external nature". The apparatus on the table is symbolic, if not of external nature, at least of the externalization of attention.

A more complete discussion of coupling would, I believe, have to deal with four elements and their relations to one another (namely, the lecturer, the audience, the physical apparatus, and the supposedly external subject-matter context), as well as with the feedback mechanisms such as the important and generally recognized one between the audience and the lecturer. For the purpose at hand, however, I can use the following limited model for the discussion of coupling in the system, and also for further elucidation of the differences between styles.

In the diagram shown here, the dotted area at the left represents the lecturer's subject field, composed of the lecturer's repertoire and knowledge in his field of science. But it also includes his own personal interests and traits. The word "subject" in subject field is therefore meant in two not clearly separate senses. For the subject of physics and the subject (lecturer) who understands this material and presents it to the class are not strictly separable. The description of "external nature" which the lecturer provides is the imaginative product of persons. A concept such as the law of conservation of energy may be regarded as one particularly useful constellation of ideas among the infinitely many possible connections that might be imagined to exist among the isolated elements of thought the lecturer possesses. Like all such patterns, they were learned by being found useful (rewarding) in the experience of the lecturer. Thus, in the subject field the connections that spell out "law of conservation of energy" are tied experiences by which the lecturer found those connections to be useful.[22]



The lens in the middle of the diagram is to symbolize the fact that the lecturer projects only a portion of his subject field into the view field of the class. The material that is being "presented", for example, the law of conservation of energy, is in more or less good focus in a view field, before the eyes of the student indicated on the right of the diagram. Let the projection be represented by an arrow; it is the avowed topic of the moment in the classroom, and the most prominent matter before the audience.

But of course in any such projection there is also, in addition to the high-fidelity image in the image plane or view field, an area of *low-fidelity* projection surrounding the central image. In terms of our analogy, the student consciously or unconsciously notices also, in addition to the law under discussion, some of those connections that are projected from the subject field which tie the lecturer's knowledge of this law to the rest of his experience and person. In my estimation, it is precisely in this area of low-fidelity, peripheral vision that the student learns a great deal more than is usually imagined. It is through communication to the student by his unfocused perception, by subliminal apprehension along the edge of the view field before him, that the student has conveyed to him much that is in addition to, or in conflict with, what the lecture avowedly teaches.[23)]

This low-fidelity area of vision seems to me in particular need of more investigation. To cite an analogy, it is not uncommon to find a student learning French tolerably well in class, but then being unable to understand it when he hears it spoken in the streets of a French town. In class, the elements of French language were presented like a crisp arrow on a clear, two-dimensional view field—whereas the language as spoken in the streets is not only a sequence of learned phrases and rules, but also a matter of varying speed, intonation, incompletion, and other peripheral intrusions. Similarly, many a student who knows science well by the book is lost when given a problem in a new context at his desk or in the laboratory. What we have perhaps not let him see sufficiently, and what confuses him at first contact, is this grainy or noisy part of the view field, which in fact attaches to everything we meet in reality.

Two Other Styles of Lecturers. The model helps us now to discern two other styles of lecturers. On the one hand there are those who tend, as it were, to project sharply delineated arrows in flat focus on a two-dimensional image plane. One might call them Sinaistic lecturers; they emit unambiguous truths, certainties as unchallengeable as the numbered Commandments. Their style comes perhaps closest to that which fits the classical theory of the lecturer, discussed earlier. At their best they can hope to approximate Boltzmann, whose precise preparation and carefully structured delivery were tempered by his great humor and humanity, and made his lecture room always overflow with students and visitors. More usually, however, such lecturers function negatively; they eliminate quickly any ambiguity of what there is to be looked at in the view field. Unresolved problems are rarely hinted at, and sometimes the Message is forced on the student with remarkable brutality. Physics is physics, and that is that. Depending on his temperament, the student may well be frightened or bored.

And on the other hand, there is the lecturer who uses, as it were, a projection lens with large depth of focus and of field, who develops to low rather than high gamma, who accentuates, consciously or unconsciously, the fringe areas that attach to the more or less predominant arrow in the view field. In lecture, he may start out on a clean line of argument; but then he wanders off in this direction or that, interrupts himself perhaps, stands for a time in silent thought, and often leaves the impression that the really interesting part of the exploration is just beyond the clearer part of the view field altogether. One might call a lecturer of this sort excursive or Exegetic. In the extreme case, the student begins to wonder whether the main arrow in the view field is worth looking at at all.[24)]

It should not be inferred that these two styles and the two mentioned before together exhaust the list of individual types. Moreover, mixtures are possible: Fig. 5 shows a Renaissance woodcut of a classroom, clearly representing, in the person of the lecturer, a Sinaistic Reducer—protected by his desk and "Silence" sign, and hewing closely to the book which his students clearly are accepting without debate as the Truth.

Fig. 5. The Lecturer: "Sinaistic Reducer".
(Reproduced from G. C. Sellery, *The Renaissance,* University of Wisconsin Press, 1950.)

Widening the View Field Through Demonstrations. In our model, the lecturer provides a form-shaping opening toward the subject field—an analogy which I have already tried to imply in the juxtaposition of Figs. 1 and 2; whether by choice or not, he also conveys peripheral information of some importance alongside the main subject of discussion. Particularly among physicists, the majority of lecturers tend to eliminate such traces from the image field, leaning toward the Sinaistic rather than the Exegetic style. In this, they err on the wrong side, perhaps for the same reason that they tend to shy away from demonstrating to the class experiential reality in its full context and instead go to lower, more abstract, more dry-cleaned levels of reality.

Happily, the lecture demonstration can be an excellent corrective for this tendency toward too rigid selection of material projected from the subject field. Particularly during manipulation, unplanned, involuntary, extemporaneous elements are conveyed to the student even by the rigorously self-contained lecturer. This may explain the experience of many students who, looking back on a science course long after, remember their lecturer best, or perhaps only, for some striking happening or accident that suddenly forced him, by his response, to put those jealously guarded extraneous elements into the view field.

The demonstration can regularly offer occasions of brief but useful unfocusing from the central view field. This speaks for lingering at length over those demonstrations that deserve it. It speaks for making informal comments not only about the purpose of the demonstration but also concerning its limits, the origin of the apparatus if it is a local relic, its historic interest where there is any, its connections with other experiments of the same sort (preferably at more primal levels of reality), etc. The student should be allowed to see the natural movement of the lecturer's mind rather than only set and posed arrangements. Bernini gave the same kind of advice when he counseled against sketching only from still models: "If a man stands still and immobile he is never as much like himself as when he moves about; movement reveals all the personal qualities which are his alone."[25]

Pathology of Demonstrations. A summary of the pathology of lectures in general and of demonstrations (including films) in particular is not in order. Several pathological traits have already been mentioned; a few others should be pointed out.

(*a*) A particular pathological practice in the use of lecture aids is summarized by the phrase *too much.* Fig. 6 is intended as a warning reminder! E. H. Hall once expressed this point very well. He was objecting to a then rising tide of belief in teaching physics entirely in terms of experimental demonstrations and the repetition of set experiments in the laboratory. The emphasis, he found, "was all on experiments and experimenting, as it should be perhaps in chemistry, but not in physics. . . . *The physicist must have time to chew the cud.* . . . To ignore this . . . is to make a serious mistake."[26]

(*b*) Another entry into the list of pathologies belongs to the category of missed opportunities. Performing a lecture demonstration can also be a creative act, whereas, for example, showing a film cannot be. Obtaining feedback from the audience, particularly from teaching assistants, is essential here. Their fresh eyes, straining from the back row, are good for testing the merits of what we think we are showing.

Tendam *et al.* came to the conclusion, unexpected for them, that "student achievement . . . is independent of distance (up to 60 feet) between the student and the lecture-demonstration experiment", whether live or filmed. The authors speculate that this may be because students learn enough from blackboard and spoken explanation so that "the actual performance of the experiment is of secondary benefit. Another explanation is that *in cases where students are told what to expect, they think that they do see it,* even though they actually do not."[27] (Italics added.)

My strongest reaction is that these findings and interpretations cast a pessimistic light on how well the full potential of live demonstrations is being exploited. In an interesting discussion of a "Free Fall Demonstration Experiment", J. Cunningham and R. Karplus found a similar effect: "Pupils who had expected the heavier object to strike first actually claimed to have observed that it did strike first!"[28] But these authors used this

Fig. 6. The Magician Ludwig Döbler, his dazzling equipment, orchestra, and audience.
(Reproduced by courtesy of Dover Publishing Co.)

finding to modify the demonstration and to take advantage of the opportunity to change the student's original *Einstellung* step by step.

Fletcher G. Watson also deplores the naïve acceptance of investigations that seem to prove the lack of special usefulness of first-hand contact with lecturers or with experiments. One danger lies in the use of test criteria that so emphasize cognitive skills (e.g. calculation and recall) that the affective domain is not examined. Another danger he discusses is illustrated by his examination of results that claimed students learned chemistry about equally well whether taught by demonstration or by performing experiments individually: "A perusal of these test items reveals that a competent student could answer completely on the basis of a textbook knowledge *without either* demonstration or laboratory work."[29] (Italics in original.)

But the most significant part of the paper for our purposes is Watson's analysis of the various studies made on the effectiveness of teaching physics by film and television, using the *Encyclopedia Britannica* films (of Professor Harvey White). While some studies, e.g. G. O. Grant's, had claimed that "the teacher-physics-film combination and conventional instruction are about equally effective", less confidence-inspiring results were reported by other studies. In one, "the scores of all non-television students were very significantly higher than those of the television students". And a detailed study including measures of interest produced a sad picture of the success of instruction regardless of medium: "On interest in physical science, there was no significant difference between the control and experimental groups. Both groups showed a mean loss of interest. On attitude toward physics as a school subject, the decline in interest of the experimental (film) group was significantly greater than that of the control group (live teachers).... While these few studies do not permit a final conclusion, they strengthen the suspicion that the *vicarious instruction increases negative attitudes toward science.*"[30] (Italics in original.)

(*c*) A third difficulty with lectures and demonstrations is a tendency for too tight coupling or too rigid programming, compounded by the continually increasing pressures on time in the lecture. Michael Faraday's chief advice, it will be recalled, was to dominate the attention of the audience *completely*. In terms of our theory of the function of lecture and demonstration, this advice was wrong. The student's attention must be allowed to wander somewhat from the main point of the presentation to its peripheral and subliminal context, and for this the demonstration can be made a particularly appropriate occasion. The eye and the mind of the student should be allowed to linger behind or run ahead of the lecturer's discourse and actions. This enhances the opportunity for discovering paradoxes, laying aside in thought or writing down questions for later examination, recognizing contexts which are not explicitly presented—in short, for keeping the learning mind active rather than passive.

Tight coupling is, however, as we have said, precisely the main characteristic of most programmed audio-visual materials, and films in particular. The screen rivets the viewer's attention. This is usually intended, so much so that according to current commercial film and TV practice there must be a change of sequence or scene or angle every ten or twenty seconds, for fear of having the spectator become bored and start thinking on his own—the most feared event in any entertainment-directed medium. For the purpose of education, however, tight coupling in the case of film is its greatest drawback.[31]

(*d*) One of the pathologies of lecture demonstrations, as has been mentioned, is that there is only a woefully underdeveloped industry behind the production of the technical aids on which we depend. Thus no manufacturer makes a desk-height projector with a short enough overhead throw and high enough magnification to allow the lecturer himself to show lantern slides, shadow projections, etc. right from the demonstration desk itself without having to cross the room every time. The need for good projectors and for hand-held 8 mm. cameras with sound has been indicated. So has the need for three-dimensional projection and for good closed-circuit TV. Very little exists by way of experience or reliable architectural advice on such matters as rotating platforms to expedite lecture demonstrations. After a century of waiting, there is no reliable clockwork-fed carbon arc in sight. Even the design of ordinary lecture-room lighting is absurdly backward, as everyone can testify who has fought with the recurring mystery of rows of inadequate switches. Only quite recently has the demonstrator been given the means to make a quick transparency of a page from a book for projection to the class. These and many similar complaints of long standing are evidences of the backwardness of the whole industry that is supposed to serve this large and nationally important market, education.

(*e*) Lastly, one must re-emphasize the pathological fascination of lecturers with replicas and lower-order reality instead of interest in bringing first- or at least second-order reality into the classroom. This may be a symptom of a more general problem: namely, that we are all too often so intrigued by models that we do not notice the beauty of the thing itself. One remembers here Jean Genet's profound indictment of the attitude of our time in his play, *Le Balcon:* history is regarded as important insofar as historic events are written about and these accounts are then read. *It is the reading that counts,* not what happened.

In science, the problem is compounded by the technique of dealing with reality quite generally by transposing our interest from the awesome, confusing, dispiriting multiplicity to another plane, that of a simpler model. Ours are much more sophisticated, more abstract models, than those of Kelvin. But it is still the model that counts. If this methodological attitude is too literally translated into pedagogic devices, the result may be a preponderance of artificial demonstrations. The harm of this is made obvious by the simple realization that the demonstration is, rightly or wrongly, the only visual-kinesthetic (i.e. nonverbal) indication to the student of what goes on in science. (His laboratory work, as generally precooked by the manual and the set equipment, is not, particularly since it usually deals with didactic reality.)

Unplanned Communication and the Role of the Hand. Our attempt at forming a theory of what the lecturer does has led us to consider the importance of the secondary or fringe area in the field that the lecturer projects. This notion will now be elaborated, with particular attention to one detail that seems to be of considerable and little-recognized importance.

In the fringe field, the subvocal, gestured, subliminal communication can be a strong, perhaps sometimes even a predominant part of the message that is apparently intended. The efficacy of such unintended communication is sometimes utterly astonishing; in the extreme it gives rise to such well-documented phenomena as the case of the animal that could perform mathematical operations—because it was somehow able to pick up almost subliminal clues giving the answers, sent out by its attendant without the latter's own knowledge.

But one does not have to go to extremes of this sort, or to Sherlock Holmes' and every fortuneteller's gift of perceiving remarkable detail from minute evidence, or to the reputed ability of some dowsers to find evidences of water from the meager clues offered by the surroundings. Subvocal, gestured, and subliminal communication is, after all, a matter of everyday experience. For example, our capability to discern a great deal from the spontaneous part of behavior is a generally operative factor. It was, I believe, Disraeli who said, "There is no index of character so sure as the voice." But this statement applies far more to the voice in natural conversation than, say, to the bland reading of a script. The latter is too tightly programmed, thereby losing information of the kind we are discussing here.

A useful distinction between "formal" and "informal" learning has been made by anthropologists, e.g. in the stimulating book by E. T. Hall, *The Silent Language.*[32] Informal communication proceeds between the lecturer and his class, whether he likes it or not. It is, of course, difficult to be precise and quantitative about these matters, and therefore they are undoubtedly not congenial to most scientists. Nevertheless, we should be prepared to find in this sort of study important clues for characterizing those lecturers who make a great deal of difference to the student.

Indeed, even from a purely evolutionary argument our sensitivity to the presence or absence of important small clues in the subliminal range is very plausible. Survival depends on the recognition of small enough signals, before such signals have risen to their full amplitude. So, too, of course, children must learn to respond to voice elements and gestures long before they understand the meaning of language and social customs. I have little doubt that these subliminal elements also play a large role in determining the difference between the good lecturer and the lecturer who is a poor teacher, although an equally competent scientist.

There is an extensive body of literature on this subject, but I have not found that it applied to the classroom situation that concerns us here. This seems a pity, since one may well expect such research to yield interesting results and improvement of the educational process if lecturers were more aware of what kind of signal transmitters they are really operating. Such a study should help in advising on the use and improvements of depiction. For it seems to me likely that artificial presentation of the person by current techniques, such as film and TV, produce so much "grain" that many of the favorably received subliminal lines in features, gestures, and voice present *in vivo* are obscured or changed by the medium. One is reminded of the experimental fact that small infants respond with a smile to the appearance of a face as long as it turns to them two eyes and a smooth brow, even if this "face" is a mask from which everything else has been eliminated. But as soon as only one eye is shown, or when the smoothness of the brow is absent, the child is neutral or shows anxiety. By analogy, we may hope to find out more than we now know of what depiction adds or subtracts on the level of the marginally perceived.

I might offer some speculations here on one particular aspect of this unexplored field of study. This has to do with the action of the hand in the manipulation of equipment. To dramatize the subject, Figs. 7a–7e show some physicists actually handling experimental or demonstration apparatus. My contention is that in the science lecture, the instructor's act and manner of touching the demonstration apparatus is a crucially important part of the view field, and for this reason should be kept clearly visible to the student.

From the earliest age a child learns through the way he is being touched[33] and through his sensation of touching the things he grasps. The primal importance of touch (with respect to food, to another person, to attack by an enemy) cannot be considered as anything but axiomatic. So, too, the new student watches how his instructor handles the apparatus which represents the subject that the student is invited to love. Everyone can recognize clearly the difference in the way a piece of equipment is held up by someone interested in entertainment and sleight-of-hand tricks, as opposed to how it is held by a craftsman who has spent a great deal of time and trouble over the piece. But I believe we should also be able to discern consciously (as the student always discerns unconsciously) the difference, among lecturers picking up apparatus, between those who enjoy performing a demonstration and those who are bored by it, or frightened by it, or who have rehearsed it too much (as is probably the case in most filmed demonstrations).

7a

7b

7c

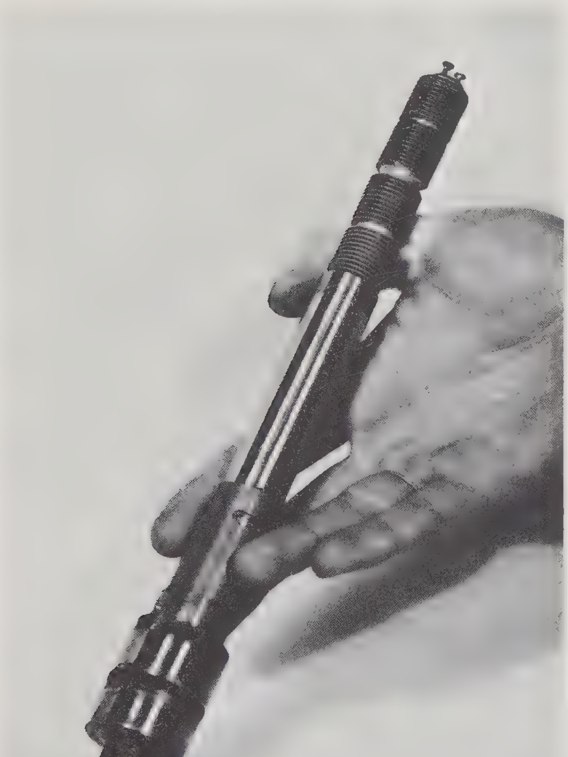
Fig. 7a. Marie Curie and radium chloride.

Fig. 7b. E. Rutherford holding N-α disintegration apparatus.

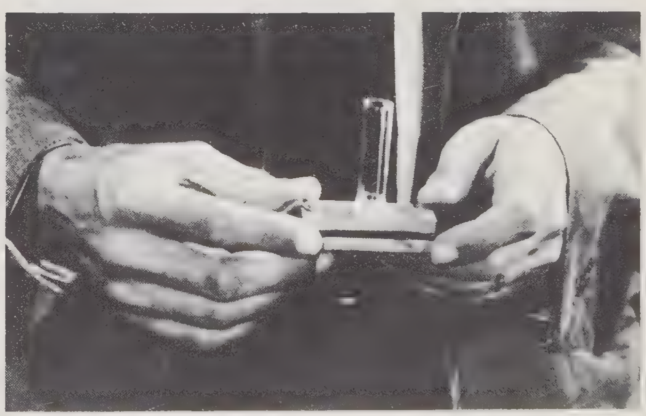
Fig. 7c. H. G. J. Moseley holding an X-ray tube.

Fig. 7d. Anonymous hand holding a high-pressure cartridge.

Fig. 7e. F. Friedman at the oil-drop apparatus.



7d



7e

Given a lecturer whose touch is, in some real sense, tender in the manipulation of demonstration equipment, one may ask if much is lost if a student, owing to poor position or distance, cannot clearly observe the hand. I am strongly inclined to believe it is. Moreover, the presence of a large audience itself will make the handling of equipment different, and less natural, from that of a small audience. Both factors argue for small lecture rooms. This is, however, not the trend of the time. Therefore, some form of closed-circuit television in the larger classroom may help to re-establish, at least partly, the intimacy on which the interest of the lecturer himself in his material always depends. Closed-circuit television for showing a close-up of the equipment being handled, as an adjunct controlled by the actual lecturer who is simultaneously active in the same room rather than as a replacement for him, seems to me a likely optimum combination for the greatest impact of demonstrations in large classes.

Here again is room for research. I believe this would also show the far greater efficacy of a lecture room so small that television is not needed at all to see the hand clearly, and that it would suggest for large courses that at least a few demonstrations be carried on in the small section meetings. This argument also favors letting the student touch the demonstration equipment himself after the lecture whenever it is possible (even if it means spacing lectures far enough apart, or bringing the demonstration table with the equipment, by way of a rotating platform, into a separate set-up area where this can be done while the next class starts in the lecture room, or placing it on a side table in the laboratory or the corridor). On the instructor's side, teaching with the aid of a lecture demonstration may have the additional merit of tending to scale his delivery to a natural speed, namely, the speed with which the hand will naturally manipulate the apparatus, whereas speech alone is often too fast, too bare of essential details, or on the contrary too dawdling. The well-thought-out demonstration has an inherent regulator by which it keeps within the scale appropriate to the capability of the student's input channels.

Physical touch is not a subject congenial to discussion in the Anglo-Saxon culture context, although even the frequency with which we use phrases that stress touch should alert us to its role: having contact with nature, knowing how to handle a subject, having a grasp on the material, etc. A closely related—and now forgotten—point was made by Newton's critic, George Berkeley, in his *New Theory of Vision*.[34] He distinguishes between "two sorts of objects apprehended by sight . . . the one properly tangible, i.e. to be perceived and measured by touch, and not immediately falling under the sense of seeing; the other, properly and immediately visible, by mediation of which the former is brought in view". He notes that an object's invariant magnitude, which we ascribe to it despite its changeable distance from us and the correspondingly changeable subtended angle it has at our eye, is at bottom an idea derived from the invariant magnitude of an object as obtained by actually touching it. The two sizes, visible and tangible, are generally thought to be the same, but strictly speaking they are not. "The magnitude or extension of the visible object . . . being immediately perceived by sight, is connected with that other which is tangible, and placed at a distance. In short, tangible length is primary, and visible length is secondary, interpreted by it."

Later Berkeley even invokes a nice, evolutionary argument for the primacy of touch:

> "Now bodies operating on our organs by an immediate application, and the hurt or advantage arising therefrom depending altogether on the tangible, and not at all on the visible, qualities of any object, this is a plain reason why those (the tangible qualities) should be regarded by us much more than these. And for this end the visive sense seems to have been bestowed on animals, to wit, that by the perception of visible ideas (which in themselves are not capable of affecting, or in any wise altering the frame of their bodies) they may be able to foresee (from the experience they have had, what tangible ideas are connected with such-and-such visible ideas) the damage or benefit which is likely to ensue, upon the application of their own bodies to this or that body which is at a distance: which foresight, how necessary it is to the preservation of an animal, everyone's experience can inform him."

The importance of touch and particularly of the hand are propositions that would have surprised perceptive people in other civilizations less than it may surprise us. The painter Renoir, for example, perceived these possibilities as a matter of course. As Jean Renoir recalls in the book *Renoir, My Father:* "He talked constantly of hands. He always judged people he saw for the first time by their hands. 'Did you see that fellow, the way he tore open his package of cigarettes; he is a scoundrel. And that woman, did you notice the way she brushed back her hair with her forefinger? A good girl.' . . . The idea that the intellect is superior to the senses was not an article of faith with him. If he had been asked to list the different parts of the human body according to their value, he would certainly have begun with the hands."

The Demonstration as Ritual. These considerations bring us finally to the last of the functions which I have tried to distinguish in the performance of the demonstration by the live lecturer. We have emphasized that such a demonstration is a creative act with some pedagogic functions that cannot otherwise be fulfilled as well or at all (e.g. in offering contact with high-order reality; in showing something beautiful, in its proper setting, to the proper time scale; or in yielding possible innovations for future classes). Second, the lecturer, the audience, and the material form a coupled system whose coupling, from moment to moment, can be adjusted by the live lecturer to be properly loose rather than hypnotically tight. Third, the lecturer, in his personal participation, emphasizes the importance of the subject by his willingness to incur risks of various sorts and degrees. Fourth, as part of the personal participation of the lecturer or demonstrator, he emits to the student subliminal but important clues concerning the subject and its practitioners, clues that appear both in the free motion of his mind and also in the manner in which he manipulates the equipment with his own hands. Fifth, the attention the lecturer gives to the demonstration equipment directs the attention of his audience away also from person-to-person relationships and serves the audience as a model of the person-subject or person-thing relationship that is basic to the scientific approach.

But one must say at least a brief word about the fact that the lecture is also a ritualistic activity, like any meeting that has a gathered audience on the one hand and a person performing before them on the other. Of course, it can be, and all too often is, *merely* a ritual, even if it is interspersed with demonstrations. As the linguist Bronislaw Malinowski asked about certain utterances, we may wonder: Are some of these lectures "used primarily to convey meaning? Certainly not! They fulfill a social function and that is their principal aim, but they are neither the result of intellectual reflection nor do they necessarily arouse reflection in the listener." They have mainly the moralizing purpose that was attached to the ceremonial public dissections still performed in England in the seventeenth century, remnants from the Middle Ages.

But "ritual" should not in itself be regarded as a bad word, even by scientists. On the contrary, ritual is a universally operating mechanism for social expression and function. For example, the externalization of attention from the lecturer's person to some object which both the demonstrator and the audience together take very seriously is a general, deeply important phenomenon. It is invoked again and again for communicating, at one and the same time, knowledge, effect, and a sense of social cohesion of the group—from the use of a flag or other symbolic device, to the function of a monstrance during mass. The experimental demonstration apparatus, held before the audience or made to operate before it, has in addition to its didactic purposes the symbolic one of stressing the importance of the occasion. (It was with this in mind that I used the word "relic" earlier in describing a certain type of demonstration apparatus that has historic meaning.) And this is by no means the only ritualistic function. One other that must be evident to everyone is the catharsis that the audience experiences when a well-managed demonstration suddenly resolves a problem or an anxiety; and then it may even, contrary to Faraday's injunction, cause applause, as at the end of a stage drama.

In looking back over these reflections on the functions and styles of demonstration, I am again struck by the number and the variety of investigations that should be taken up by those interested in research on such topics. Needless to say, neither such an article nor such research can hope to tell any individual lecturer directly and immediately what practical changes in style and manner he should make. There is no common mold. We can each only do what is appropriate to our temperament and training. And even that we learn only very slowly.

But one can become better aware of what one's own style and traits *are,* and so take advantage of one's own best potential. And in the long run, one may expect to learn possible ways of improving the present state of our art. We may even find in such a study the answer to a curious puzzle: why even the hastily prepared and half-visible demonstrations in so many of our science courses are, after all, sometimes so remarkably effective.

1. E. Smith, "Early History of the High School", Annual Report of the School Committee, Cambridge, Massachusetts (1892), p. 54. Cited by Sidney Rosen in *American Journal of Physics* (22: 1954) p. 194.
2. This was the case with Kepler, Young, Helmholtz, and Rutherford. On beginning his career as mathematics teacher in Graz, Kepler, in part because of his poor delivery, "had only a few listeners the first year, and none at all the second". (M. Caspar, *Kepler,* New York, 1962, p. 59.) Max Planck, recalling his student days, said: "I must confess that the lectures of these men netted me no perceptible gain. It was obvious that Helmholtz never prepared his lectures properly. He spoke haltingly, and would interrupt his discourse to look for the necessary data in his small notebook; moreover, he repeatedly made mistakes in his calculations at the blackboard, and we had the unmistakable impression that the class bored him as much as it did us. Eventually, his classes became more and more deserted, and finally they were attended by only three students; I was one of the three. . . ." (Max Planck, *Scientific Autobiography and Other Papers,* transl. by Frank Gaynor, New York, Philosophical Library, 1949, p. 15.)
3. *Albert Einstein: Philosopher-Scientist,* P. A. Schilpp, ed., Evanston, Illinois (1949), p. 15.
4. E.g. on the last of these, see C. Ramsauer, *Grundversuche der Physik in historischer Darstellung,* Berlin, V. I. Springer (1953), p. 169: "In 1886, it occurred to Hertz, while using a pair of Riess coils for lecture demonstration purposes, that a very weak discharge in one of the coils is enough to cause sparks in the other. . . ." This was the beginning of his work on electromagnetic waves.
5. In an article for *The American Statistician,* quoted in the *Portland Telegram* (March 24, 1963). See also the remark of E. M. Rogers in the *Proceedings of the Wesleyan Conference on Lecture Demonstrations* (1959), p. 6: "So I look forward to good physics teaching going on fifty years from now, but mostly by film and TV, from sheer demand of numbers."
6. *American Journal of Physics* (30: 1962) pp. 594–601.
7. Fletcher G. Watson, "Research on Teaching Science", in *Handbook of Research on Teaching,* N. L. Gage, American Educational Research Association (1963), p. 1044. But Watson adds: "Nonetheless this conclusion is still open to question," and he goes on to subject the studies to a detailed examination—with disturbing results which will be noted below.
8. *Advice to a Lecturer,* published by the Royal Institution, London. The brief pamphlet is an anthology largely taken from *The Life and Letters of Faraday* by Bence Jones (1869). Faraday entered the Royal Institution as a laboratory assistant in March 1813 and later, for over thirty years, "was the foremost scientific lecturer in London or indeed the whole of England".
9. Private communication from Professor S. C. Brown.
10. The older classical theory comes through at various points in the *Proceedings of the Wesleyan University Conference on Lecture Demonstration* (1959), for example, in the first address, by V. L. Bollman. Another interesting exposition of that type is the contribution by the Soviet physicist A. S. Akhmatov in the *Proceedings of the International Conference on Physics Education,* Paris (1960), pp. 133–134. A severely classical attitude pervades the otherwise valuable collection by A. B. Mlodzeevskii, *Lecture Demonstrations in Physics,* available in translation in a condensation by H. A. Robinson (April 1963), on microfilm from the American Institute of Physics.
11. This is well discussed by Martin Deutsch in "Evidence and Inference in Nuclear Research", in *Daedalus* 87, 4 (Fall, 1958) pp. 88–98. He stresses that "in a typical modern physics experiment . . . the direct sensory impressions of the experimental situation are not only not very helpful to the solution of the problem investigated, but are not even likely to reveal the relevant factors".
12. *Curator* 5, No. 2 (1962) p. 119.
13. There are other good reasons for preserving historically significant scientific equipment; they are given in the pamphlet "Scientific Instruments and Apparatus: Sources for the Fuller Documentation of the History of Physics", Pub. R–152, obtainable gratis by writing to the Director, History of Physics Project, American Institute of Physics, 335 East 45th Street, New York 17, New York.
14. See also R. T. Sanderson, *Teaching Chemistry with Models,* Princeton, N.J., Van Nostrand (1962).
15. "The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be 'voluntarily' reproduced or combined." (Hadamard, *The Psychology of Invention in the Mathematical Field,* New York, Dover Publications, 1954, p. 142.)
16. Recently my attention has been drawn to Edgar Dale's *Audio-Visual Methods in Teaching,* rev. ed., New York, The Dryden Press (1954). In Chapter 4, Dale uses "a pictorial device", which he calls a "Cone of Experience", some of whose sections seem to be related to the levels proposed above. At the very least, these two heuristic schemes share the desire not to be misunderstood as introducing rigid, inflexible divisions.
17. Professor S. C. Brown informs me that ever since C. V.

Boys ran away once just before his scheduled Friday evening lecture at the Royal Institution, lecturers are physically locked into Faraday's study at the Institution for half an hour before they are to start, lest stage fright force another cancellation!

18. *Science* 126 (1957) pp. 384–390.
19. And when even the student himself avoids participating in experiments, e.g. by being forced to watch "laboratory experiments" done for him on film or TV, then it is difficult to see why it should be thought that he is still studying nature and nature's laws.

    One may add here that in an age when replacement of the person by his surrogate is more and more usual, it should surely be interesting to study what the full effect of these differences is, before students are handed over to what a recent American Association for the Advancement of Science brochure has greeted as "the technological classroom". For example, the study by Tendam *et al.* (*op. cit.*) suggests that teaching by film is noticeably less effective than by means of a live teacher in the case of students of above average ability. A similar conclusion has been noted by F. G. Watson, cited above.
20. Address at Eastern Theoretical Physics Conference, University of Virginia, October 26, 1962.
21. See J. J. Gibson, *The Perception of the Visual World,* Boston, Houghton Mifflin Co. (1950).
22. The strict operationalist would go further and say that the meaning of a conception such as the law of conservation of energy resides only in what a person can do to demonstrate its validity; he must therefore sanction his lecturing on the law by recalling how he himself has acted in the past, and by imagining how he will act again in the future, while exhibiting the operation of the law.
23. A closely related concept of the process of apprehension by "subception" has been discussed in a stimulating article by M. Polanyi, "Tacit Knowing", in *Review of Modern Physics* 34 (1962) pp. 601–616.
24. An example seems to have been Maxwell. "As a teacher of general physics he was not a success. Ideas would occur to him as he lectured to divert him from the path he had intended. Bending over their notebooks, his students could not follow." C. C. Gillispie, *The Edge of Objectivity,* Princeton, Princeton University Press (1960), p. 478. As Professor A. Bork has pointed out to me, a more detailed estimate is given by Lewis Campbell and William Garnett, *Life of James Clerk Maxwell,* New York, Macmillan (1884), pp. 175–177.

    Though Einstein was strongly partial to the cause of good teaching—Carl Seelig reports his opinion "gute Physiker gebe es genug, hingegen immer noch zu wenige fähige Lehrer"—he shared some of Maxwell's characteristics in larger classes. So did Rutherford; see W. A. Kay and S. Devons, "Recollections of Rutherford", in *The Natural Philosopher* 1 (1963) p. 155.
25. Cited by J. Ackerman in *Seventeenth Century Science and the Arts,* H. H. Rhys, ed., Princeton, Princeton University Press (1961), p. 84.
26. Bulletin No. 2, Proceedings of the Third Annual Conference, New York State Science Teachers Association, New York University, 1899, p. 585. Cited by S. Rosen, in *American Journal of Physics* 22 (1954) p. 202. (Italics added.)
27. *Op. cit.*
28. *American Journal of Physics* 30 (1962) p. 656.
29. *Op. cit.*
30. G. O. Grant, *A Study of the Teaching of Physics by Film and Television,* New York, American Institute of Physics (1958).
31. I noticed a similar opinion concerning the "canned" lectures that are now being broadcast in some museums. See A. E. Parr, *Curator* 4, No. 1 (1961) p. 47.
32. Doubleday, New York (1959) and also in paperback edition.

    Since writing the bulk of this essay, I have noted the publication of an interesting article by E. B. McNeil, "Physics Teaching: An Anthropological Angle" (*American Journal of Physics* 31, 1963, p. 774), which is also influenced by some ideas of Hall's. I find McNeil's suggestions congenial. Another stimulating source is the work of L. K. Frank.
33. One recalls here the case study of the hospitalized infants who, despite excellent care, would not thrive, until it was discovered that for full physical well-being, the children had to be occasionally picked up and held by the nurses instead of being left in their safe cribs.
34. No. 483, Everyman's Library, republished by J. M. Dent and Sons, Ltd., London (1925), pp. 36–39. The passage was brought to my attention by S. Goldberg.

DESIGN AND COMMUNICATION

From stone-age cave paintings to Dead Sea scrolls, from Gutenberg's typographic innovation to the binary system of the electronic computer, there is a steady development toward the refinement of meaning and the mechanization of communication. The stages of this growth reflect the increasing volume of knowledge to be communicated, employed and preserved for use by more people. They also indicate the rising specialization in man's activities which is changing our present environment at a still accelerating pace.

The transmission, from one generation to the next, of more or less ordered systems of data which represent knowledge is a function of education. The storage of such data in the form of recognizable symbols is a function of all communication techniques, old or new.

Our cultural heritage has been immensely enriched by a vocabulary of communication devices of well-defined recognition values, be they shapes, colors, letters, signs, songs, music, or line drawings, paintings, sculptures, even certain aspects of architecture. In addition, technical innovations have been introduced during the last hundred years—mass printing, photography, the film, television, electronics, to name only a few—which have brought an entirely new range of creative possibilities to express thoughts more efficiently and to influence more people than ever before in history.

Availability of more means by which communications can be facilitated, a gradual realization of complexities due to their wider range and vast specialization in information data, uncovered new problems in the shaping of communications. It seems reasonable that they cannot always be met by traditional procedures, which are based on concepts of an earlier stage in our social development. There are new professions, new human needs, new ideas and inspirations, a general speed-up in the interchange of experiences, and the commercialization of communications on a world scale, all of which combine into a problem which is summarized by the term "communication explosion".

In one single area of medicine alone, information which is gathered in published form in one year would take about 20 years of uninterrupted reading by one person. If one multiplies this situation only moderately by activities in similar professions, it becomes apparent that the human ability to retain and remember information faces an unprecedented task. We must strive now for new methods of evaluation in order to establish a better balance between the wealth of knowledge available and retained, and the enjoyment of its benefits by more people.

Seen within this frame of reference, communication designers may be destined to play a vital role in the future, because it is the essential function of their profession in our society to enhance and cultivate communications toward:

1. easier understanding of ideas and complex problems, in the shortest possible time, and
2. higher visual and auditory retention of data.

The case studies which accompany this article illustrate both objectives. They are visual models, designed to reveal, explain and demonstrate the organization and functioning of structures, organs and processes in the human body.

Scientific information about each of the areas with which the models deal is of such a volume and many-faceted specialization that it is often difficult for scientist and lay public to understand the significance of recent discoveries unless they appear as parts related to an over-all image—a model. The commercial needs of an American pharmaceutical concern • coincided with this design objective and led to their sponsorship of the case study project.

The problem, as stated initially to the designer, was to select an area of medical research and recent advances that would be of basic importance to the whole field of medicine and health, suitable for comprehensive and effective demonstration and a possibly dramatic interpretation of ideas. Through the design, random bits and sectors of information were to be "pulled together" into a logical relationship to each other and to the demonstration as a whole.

•
The Upjohn Company, Kalamazoo, Michigan.

CASE STUDY I BASIC CELL

Following an initial research stage, which consisted of the study of medical literature, interviews with physicians, biologists, molecular chemists and geneticists, I proposed—as a first step in a medical communications program—the construction of a three-dimensional model of a cell, the basic unit of life.

Included in this effort was also the study of films, of illustrative techniques used so far, and especially of the new electron-micrographic observations at a number of American research institutions. This resulted not only in clear indications for the usefulness of a comprehensive cell model for the medical practitioner, but more so for the need for such a three-dimensional demonstration in educational fields.

Many separately conducted cell research activities were taking place all over the world in universities and research laboratories, and this concentrated work on the tiny universe of the cell had resulted in different and seemingly contradictory conclusions. Also, a somewhat narrow interpretation of electron-micrographs of cell cross sections had inhibited estimates of what a whole cell would look like. However, the wealth of documentation and the steady flow of information from participating scientists not only made the direction of the design effort clear but also gave assurance that we could count on a successful outcome of the project.

After building a first small-scale model, a critical review by scientists of all its parts took place, until the specialized functions of cell division, heredity, molecular chemistry and energy storage had also been considered and integrated. After this the building of a large and final model could be undertaken.

A structure of this type and size had not been built before and special technical devices had to be developed for almost every manufacturing step. The outer layer of the cell—the cytoplasm—was based on a prefabricated five-piece module of clear plastic tubes, interlocked at many joints. They produced a frothy, cloud-like over-all effect. Within this tubular construction were imbedded the active cell parts—the organels—such as the endoplasmic reticula, centrosome, mitochondria, fat globules, the nucleus with its chromosomes and the nucleolus. Red, glowing dot patterns of specific arrangements were placed on the membrane of the cell's nucleus and on the endoplasmic reticula to indicate the system of energy transfer within the cell. Only the upper half of the cell was built and placed on a metal mirror so that the visitor, by walking inside the structure, found himself visually suspended in the horizontal center of a sphere which stretched away from him in all directions.

The completed model accomplished at a glance what the combination of existing means of information had failed to do: it produced an immediate appreciation of a cell's logical structure and functioning. To this one had to add the visual attraction which resulted from the qualities of forms, materials, lights and colors; all integrated toward a clear understanding of the whole.

Wherever the basic cell model was exhibited, in this country and abroad, biologists, biochemists and educators commented favorably on its informational aspects. Even when reservations about methods of structural interpretation were expressed, the positive educational value of the model as a whole was emphasized strongly.

Figs. 1a–1c. Structural Model of a Basic Cell

This exhibit represents a generalized view of an average cell before it develops specialized features that would change it into a muscle cell, a blood cell, a brain cell or an insulin cell. The structure was designed to demonstrate scale and functional relationships between *active* cell parts—the organels—and the *supporting* parts—such as cytoplasm and membrane.

Measuring 24 feet across and 12 feet high, the model represented an approximate magnification of 1:1,000,000.

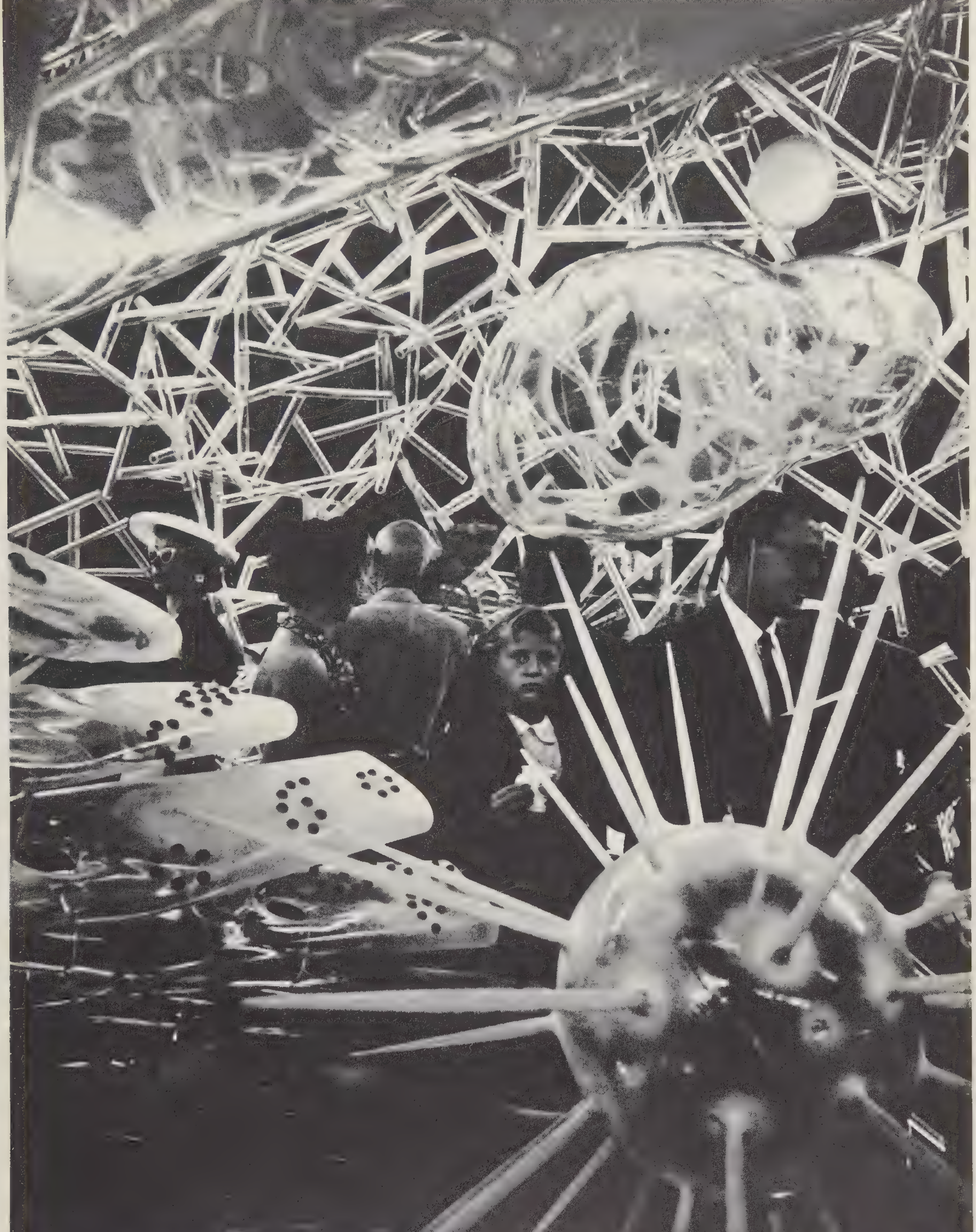
The scale was determined by the design aim to make it possible for people to walk inside and around, to receive a physical impression of the whole and its parts. While this scale produced the need for certain abstractions in shaping and symbolizing individual parts—in terms of materials and function interpretations—the interplay between human size, human motion and optical experience produced quick understanding and memorization of interrelated cell functions. The relationship between the size of the model and the audience can be seen in Fig. 1c, a photograph taken during one of the public showings.

In the center of this walk-in exhibit, the nucleus is covered by a membrane under which one can see the coiled structures of chromosomes that surround the nucleolus, the center of the nucleus itself. The small sphere whose tentacles stretch in all directions represents a centrosome—an organel essential for cell division. The oblong oval body above it represents one of the many mitochondria in a cell—organels which convert food into energy. Connecting nucleus, centrosome and mitochondrion are the curved, hollow volumes, of endoplasmic reticulum—organels necessary for the distribution of chemical substances throughout the cell.

The sole light source used in the exhibit was inside the nucleolus. The light-transmitting character of lucite plastic was employed to produce illumination from this light source throughout the entire structure. Wherever strong light accents were desired the plastic was sand-blasted to trap additional light. Rhythmic illumination of high and low intensity was employed to create an illusion of expansion and contraction, as if the structure were "breathing".

1a

1b



1c

Figs. 2a–2b. Anatomical Model of a Basic Cell
(*Photos Ezra Stroller Associates*)

This model, also in plastic, was constructed shortly after the introduction of the large 24-foot structure. The motivations for this project were:

1. Heavy demands for exhibiting the large model, coming from all parts of the world;
2. The need for avoiding a too literal acceptance of partly abstract and—in some instances—symbolic interpretation of structural details;
3. New definitions about relationships and functions of three organels to the rest of the cell had emerged which in part had been encouraged by the first cell model. These definitions dealt especially with the appearance and activities of the Golgi system, the centrosome and the endoplasmic reticulum.

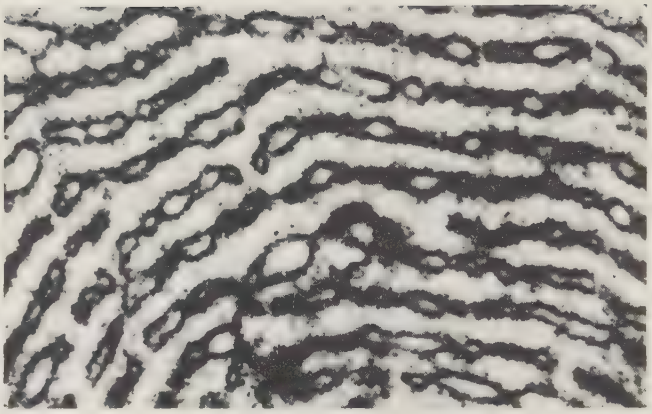
Fig. 2a shows the scale of a human figure to the 6-foot model. The upper half of the cell membrane has been cut away to show the cell's interior, and one can see clearly the shape and relationship of the dark Golgi system to the cell nucleus. Also the distribution of mitochondrial bodies throughout the cell's volume is demonstrated. Cytoplasm is shown now as a continuous layer of interlacing thin tubes.

The interior view in Fig. 2b reveals organic-structural relationships that had not been understood before. Connections between centrosome, cytoplasm, nucleus and endoplasmic reticulum through the network of cytoplasm, all became visible at once. This photograph has appeared in all new textbooks on cytology around the world.

2a


2b

Fig. 3a. Electron-micrograph of endoplasmic reticulum ordered in spheric layers around the cell's nucleus.



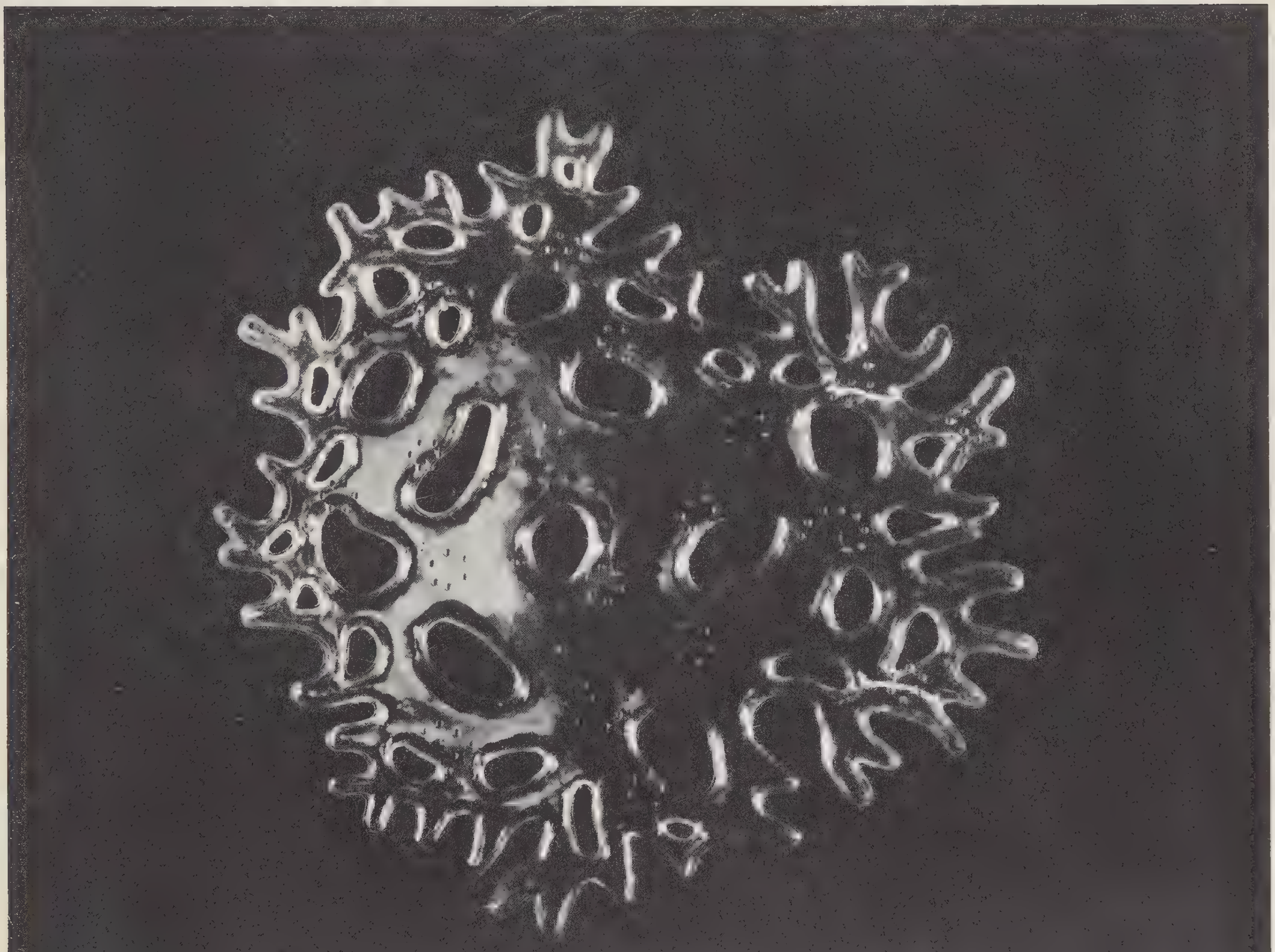
3a

More than 100 of such structures as that seen in Fig. 3b, measuring approximately 30 x 30 inches, were used in the 6-foot anatomical cell model. Each reticulum is a curved segment of a layer of spheres whose center is the nucleus.

The electron-micrograph seen in Fig. 3a is the evidence from which the final appearance of this organel was estimated. It shows cross sections of endoplasmic reticulum layers, in which the spaces within each layer represent the oval holes of the model plate and intervals between the reticula.

The method of producing this model consisted of designing a top and bottom "skin". Both were vacuum-formed and attached to each other to show that this organel had two surfaces which enclosed a liquid void. Over both outer surfaces "float" the ribonucleic particles emanating from the cell's nucleus. Through the holes pass the cytoplasmic tubes, or strands, which hold the layers of endoplasmic reticula in place, aside from fulfilling other tasks.

Fig. 3b. Detailed portrait of an endoplasmic reticulum.



3b

CASE STUDY II AUDIO-VISUAL EXPERIENCE

The success of the cell model brought demands for more designs of this type. Along with the cell project I had proposed earlier that not only submicroscopic structures but processes too should be demonstrated visually. Consequently, another project was launched, whose objective was a demonstration of the evolution of a thought in the human brain.

In "thinking about thinking", a great deal of progress had been made in recent years by a branch of science concerned with the brain's anatomical, psycho-physical and chemical functioning. New tools had become available for research and for treatment of disorders, which yielded reports of an accuracy unknown before—among them electron-encephalography, sound and visual records of memory tests, electronically recorded minute fluctuations in the behavior of various brain centers and their relationships to glandular functions. These studies were also branching out into the fields of anthropology, cybernetics, hypnosis and psychiatry, and produced an impressive volume of literature, case reports, films and theoretical material.

The design problem was defined in the direction of searching for a type of visual-auditory demonstration which would point out the order by which the main product of the brain, a thought, evolves. At a relatively early stage of the design investigation, it became evident that to remain understandable the form of this demonstration should not be based on the anatomical geography of the organ, but perhaps on the sequential order of the thinking process itself. Following this, a time-space model was proposed which would concentrate on the interlocking actions of the two most prominent sensory mechanisms in the brain—sight and hearing.

At first a series of small-scale models was made, into which the known evolution of sensory actions was composed. Locations and distances were so arranged that motion and timing of colored light impulses could be followed by an observer. Selected for a theme was the experience of a singer and her song, both familiar to most people. The sounds and description of the auditory aspects of the experience could be *listened to* over earphones placed near seats around the front of the exhibit, while the motion of green, coded *sound impulses* could be followed visually in the model. The visual aspects of the experience could be seen throughout the performance, as they were cross-related to memory flashbacks, and resulted in the final recording of the specific image as red, coded light patterns in memory cortices and midbrain, next to the green patterns of sound. The duration of the actual experience was estimated to last one second, but it took twelve minutes to record its sequences clearly. Within this time limit the demonstration was repeated three times. First came the visual, second the auditory, and then the combination of both sequences.

The finished exhibit model was effective because its complicated actions appeared as understandable parts of a process which the model's form had been designed to contain. However, in testing its performances, the scientists who had worked with me on "the brain" found that, by adding minor electronic devices, the program could be extended beyond this designed range; consequently, for certain professional audiences, there could be added demonstrations of functional aspects of learning, growth, senility, schizophrenia, storage and utilization of experiences, and indications of the estimated mechanism of intuition. Since its first showing, the model has performed to medical and lay audiences in many American cities and in Italy, Holland and England. It was also featured in televised lectures, motion pictures and many publications throughout the world.

From the beginning of this project, the integration of *all* senses of perception—sight, hearing, smell, taste and touch—in one model was tempting. In the course of research and construction, I had to accept with reluctance the fact that it would be extraordinarily difficult to harmonize this intent with the demands for clear and understandable communication. I also found that important aspects of such an integrated total experience are not yet fully understood, but I have not relinquished hope that such a model can be made in the future, possibly based on an entirely different form of presentation, one which combines three-dimensional and film elements. The scale of such a demonstration may have to be many times larger than the one employed in the existing "brain" model, so that it can explain not only the order of five sensory experiences but their constantly changing interactions as well.

Figs. 4a–4c. Model of an Audio-Visual Experience.
(*Photos Ezra Stroller Associates*)

This electronically controlled structure was designed to demonstrate the order by which the human brain reacts to, and acts upon, the information that is created by an audio-visual experience.

Designed for easy assembly and dismantling, and built of aluminum, the demonstration of the model can be viewed by 100 seated people at a time. Each seat is equipped with an earphone, over which sounds and a verbal explanation in four languages are transmitted. Whereas the cell structure is static and the audience moves, the reversed procedure is employed here insofar as the audience is seated and demonstrations move from station to station.

Eyes and ears are represented by half-spheres, nerve pathways by tubes, nerve centers by small full spheres, and cortices by large concave disks. The midbrain is represented by a large concave disk and placed at the floor of the exhibit. The large flat disk at the upper center is a projection screen denoting through photographic transparencies various stages of awareness and associative meanings of an experience. Throughout the exhibit, red denotes visual, and green auditory, aspects of an experience. The scale of the exhibit was determined by the need for easily understandable time and space relationship. The concentric shape of the exhibit developed from the "double-check" system of the human brain, by which every experience is recorded, analyzed and decided upon twice and—presumably—simultaneously.

"A moment at a concert" is the experience which this model analyzes. At the moment the image of a singer is projected and her voice is heard, light impulses travel from eyes and ears over the nerve pathways to the nerve centers (geniculates).

On the way to these nerve centers a first vague impression of the experience is laid down as a red-green light pattern in the midbrain (floor). From the geniculates lights travel to the visual cortices (pair of discs in the rear) and auditory cortices (pair of discs above the large discs at left and right). Here a definite impression of the experience is shaped, and compared for accuracy between both cortices of each sense. Then an impulse returns to the midbrain, where the initial, vague experience-pattern lights up more strongly, sending coded impulses to the two large memory cortices (left and right).

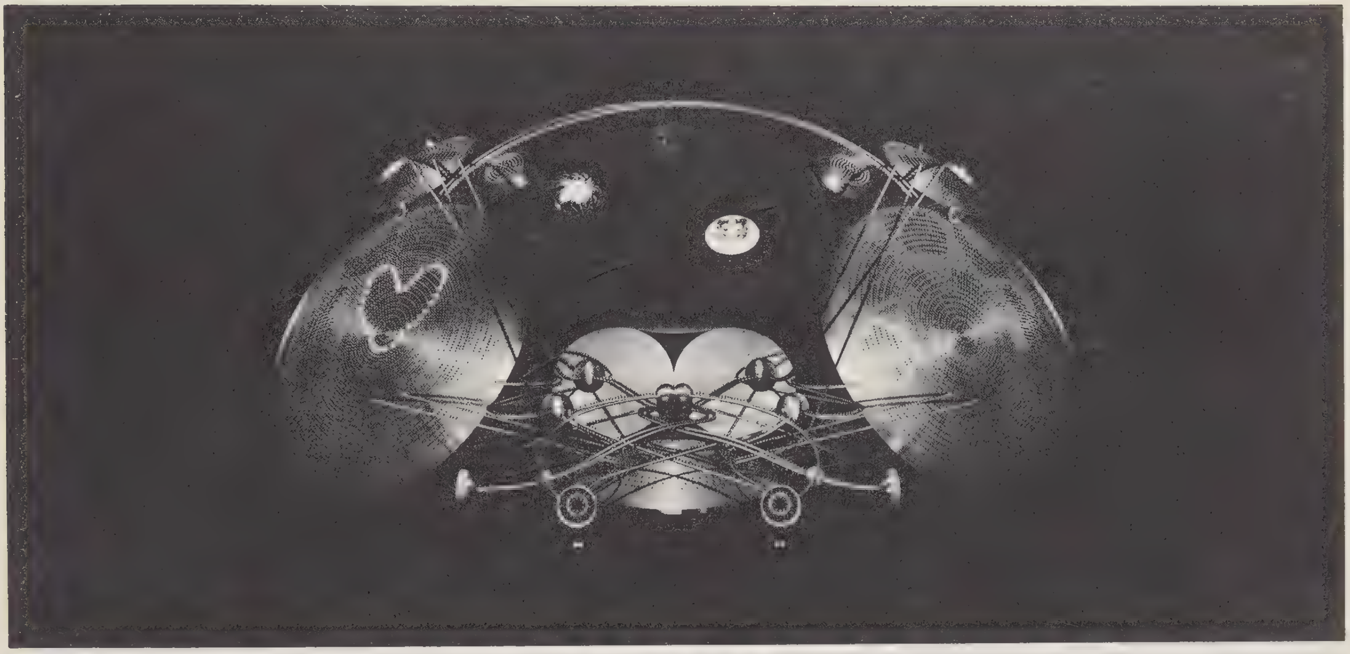
Here the experience pattern laid down in midbrain and visual-auditory cortices is compared with earlier experience-patterns stored there. These light up at first as random shapes and finally as dual, equal light-patterns.

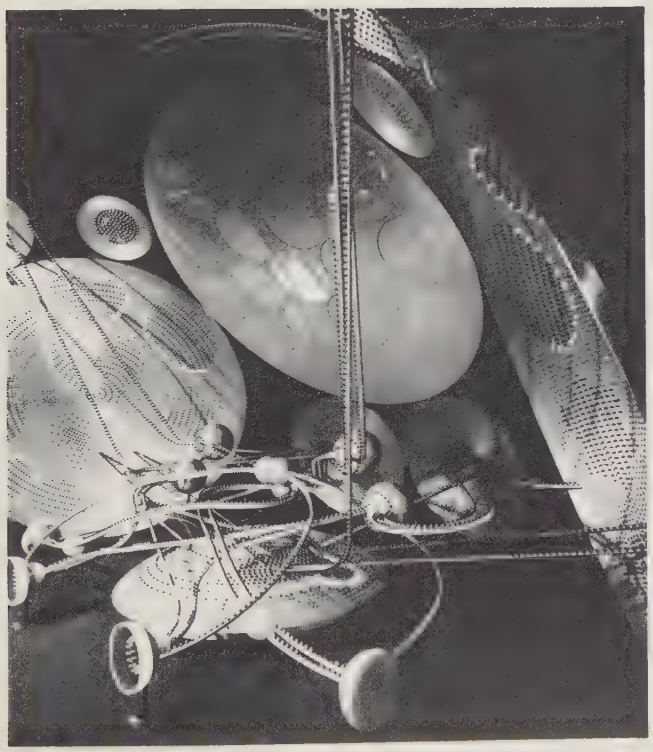
As it is established that the new experience is different, and to what extent it is different from earlier ones, a dual replica of the light-pattern on the midbrain is deposited on the memory cortices. Thereupon the midbrain's red-green pattern flares up still more intensively, indicating that memory comparisons have isolated and defined the specific value of the experience and that the brain as a whole is now fully conscious of it. As red and green impulses travel over the curved nerve pathways connecting both memory cortices (on top), the midbrain releases impulses to the motor cortices (small pair of discs, above the large, memory discs at left and right) which in turn trigger a response: applause to the singer's concert.

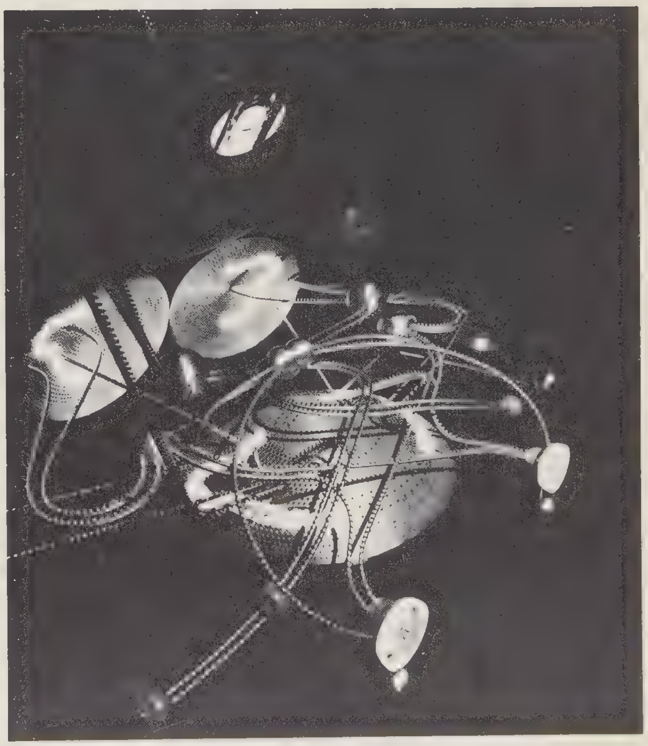
On the projection disc color-photographic images flare up at intervals to denote increasingly precise associative meanings of light-patterns, especially in the memory cortices. The demonstration ends with the image of the singer, at the screen's center, lighting up once more as the applause is heard over the earphones.

A singer is seen on the projection screen at the beginning of the performance. The brain model responds to the visual experience in the following manner:

1. the eyes (half-spheres) light up and red light impulses travel to the geniculates, from where white impulses return to adjust eye muscles until the singer is in correct focus,
2. then red light impulses travel to midbrain, visual geniculates, and cortices, and
3. deposit experience-patterns on midbrain and visual cortices.


4a


4b


4c

CASE STUDY III METABOLIC PROCESS

A subsequent case study in this series of information exhibits, organized by the sponsoring pharmaceutical firm, dealt with metabolism. Here too, was a subject of considerable importance, with complex data coming from many branches of biological, nutritional and chemical research. The volume of literature on metabolism, and the rate at which new information accumulated, were so formidable that a Presidential commission was formed a few years ago to study means of condensing information, so that further progress should not be hindered by communication difficulties.

The design was based on the idea that metabolism is the process of life, which is a continuous cycle of energy *production* and energy *use* that turns into *new* energy *production*. This principle was expressed through a continuous eight-ring spiral structure, into which the observer could walk to watch performances in eight spheres, one fastened to each ring. Each of these spheres showed metabolic events and the end product of each event was the "starter" product of the next. The spiral rings, containing moving lights, came together in the center of the circular exhibit, where a structure of a mitochondrion—the chemical power center of the cell—was placed. Lights moved on the inside of the rings into this center from where they emerged again visibly strengthened, to flow to a sphere. Here they set off the light and color sequence of a metabolic event. Upon its completion the lights emerged again at the bottom of the sphere to return via the spiral ring to the center, to move from there into the next sphere. Thus, the motion of light guided the observer from one sphere to the next, as he walked around on the circular platform.

Shapes, colors, symbols, electron-micrographic enlargements, scale, light movements and timing, were coordinated in such a way that the characteristic details of metabolic processes revealed themselves almost without text. This accounts for the continuous success of the exhibit with both scientifically sophisticated and lay audiences.

The evaluation of experiences and lessons growing out of the case studies shown here, of others which are being developed, and of related graphic work, suggest conclusions which may have a bearing on the future scope of communication design.

It seems necessary to remember that "models" of thoughts, structures, or processes need not always be visual in a representational-image sense. There are verbal models, or graphs, or typography, or colors, that may be suitable vehicles to explain ideas with a maximum of efficiency and a minimum of means. One must also keep the difference between explanation and the real event, or fact constantly in mind. The first is a symbolic and tentative interpretation by which we establish contact between human ideas, or knowledge, and people. The second is at times elusive and its meaning may not always be translatable without distortion. For example, the isolation of one aspect of observation from its environment already harbors seeds of misunderstanding, and a consequent misjudgment by the person who receives the information. Therefore, a communication designer should see his craft as the link *between* the realm of ideas and the reality of people. Understanding of both is his highest challenge and biggest reward.

On occasions, I observed among scientists considerable opposition to *any* visualization or popularization of their problems. Often this was due to unfamiliarity with the potential nature of design, with the range of presentation and the techniques of mass communications. But if held against a "normal" ignorance about science by designers, their absorbing preoccupation with commercial objectives, and an aesthetic isolation which art training can produce, it appears that there is substance to the weariness of scientists. The difficulties can be substantially reduced by increasing the familiarity of designers with science and by the quality of their performance in the service of ideas.

However, while science communications are one important area of design, it is necessary to remain alert to other problems which design must solve in contemporary life. Many of these problems are of such high social importance that the methods of design may have to be re-assessed scientifically to assure accurate understanding as well as persuasion. This implies the need for a thoughtful decision by a designer as to the values which he attaches to the aesthetic and intellectual formulation of each design solution and the moral responsibility which his work carries.

In professional ways, we have an arsenal of expressive means at our disposal such as no other generation of designers has had before. If the thrust of design is in the direction of clarity *and* beauty of a final design solution, the means employed will not dominate but serve purpose. Designers should have a range of professional competence by which they can turn from the motions of lights to the collage, from the graph to a motion picture, from a three-dimensional model to a television sequence, from color and sound to letter forms, if that serves the purpose of a clearer, more eloquent, more stimulating, simpler communication which improves the quality of our human environment.

Figs. 5a–5d. Model of the Metabolic Process

As a design problem, this model had to solve three problems on a visual level:

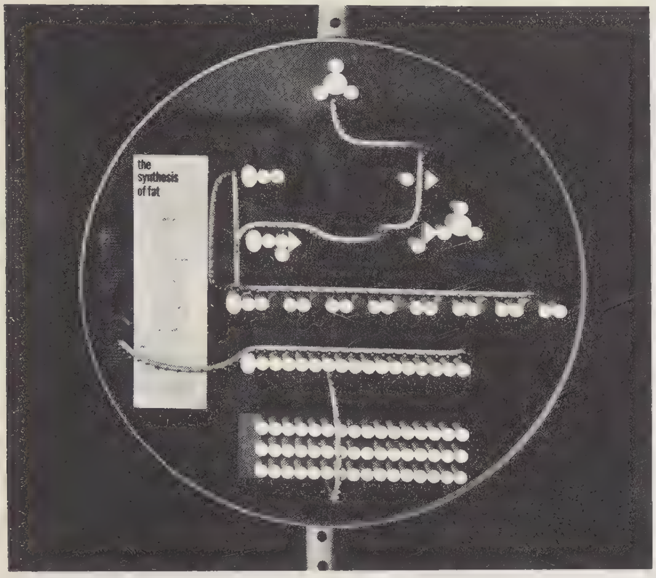
1. To determine the method by which specific examples of metabolic processes could be organized and interrelated;
2. To make three-dimensional space, vertical and horizontal motion and "natural" left-to-right reading habits lead an audience to appreciation and understanding of the logic of life-preserving mechanics,
3. To find a suitable over-all form that would communicate the meaning of 1 and 2.

A schematic presentation of a mitochondrion, referred to by biochemists as the "powerhouse" of the cell, is seen at the center of the exhibit. An eight-ring continuous spiral winds through the mitochondrion. The spiral is made of steel pipes perforated to show a continuous chain of moving electric lights which emanate from the mitochondrion at the top and return to it at the bottom. Following this motion, at reading height in eight half-spheres, important specific chemical transitions are demonstrated through moving light and color sequences which start at the moment the lights from the spiral enter into the top half-spheres. When the motion inside the half-spheres is completed, light in the spiral pipe commences from below the half-sphere and returns into the mitochondrion, there to be charged again for the next metabolic sequence in the next half-sphere.

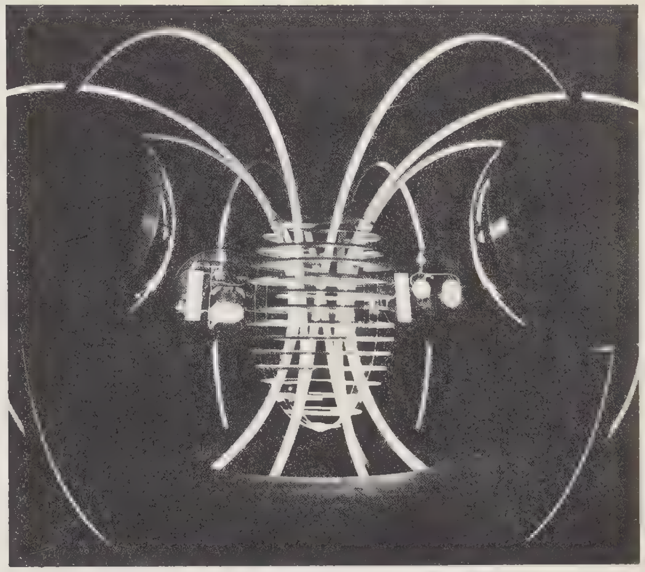
Thus, the cyclic principle "energy *production* plus energy *use* equals *new* energy for energy *production*" is expressed. A raised circular platform, accessible from all sides and seemingly suspended inside the spiral, connects all eight demonstrations that deal with the utilization and production of fat, sugar, heat, etc. All that is demanded of the spectator is that he follow—visually and physically—the motion of the lights.

The viewer quickly becomes aware of a uniform visual coding system in terms of light-spacing, colors and shapes—designed to convey the meaning of unfamiliar and complex chemical transformations with ease and precision.

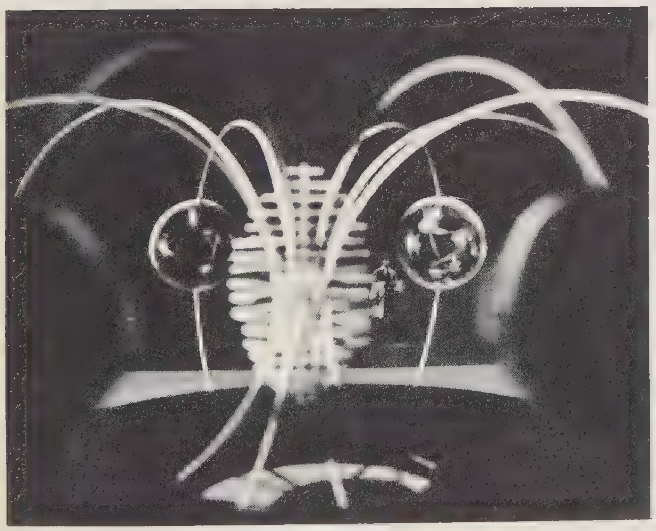
The complete structure contained an electronic system which adjusted and coordinated the speed of the lights and of the motion of colors to the varying professional sophistication or educational standards of audiences. Thus it was possible to "design" automatically the timing of the motions of large groups of people into a predictable pace without apparent pressure or signs, thereby avoiding unnecessary waiting periods which in convention meetings often result in loss of interest and the fragmentation of communication.



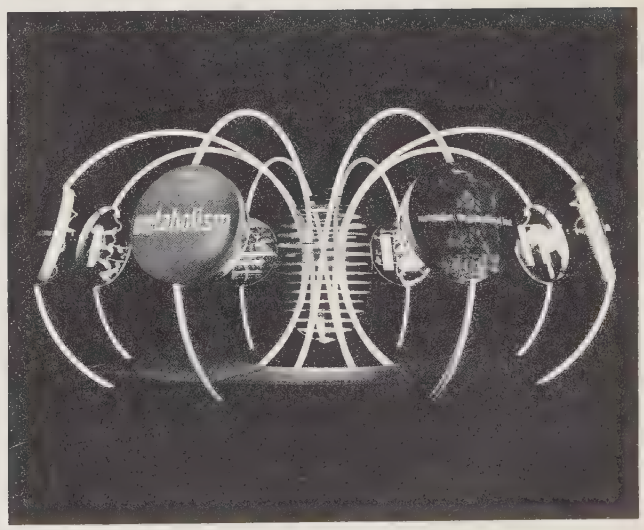
5a



5b



5c



5d

WILLIAM J. J. GORDON

THE METAPHORICAL WAY OF KNOWING

This paper is a report of a simple experiment in educating college students to use metaphor and visual images for understanding science.• However, a description of this experiment would be irrelevant unless the reader is made aware of certain prior research in the field.

Over twenty years ago the author became intrigued with the possibility of increasing the inventive output of individuals and groups. This particular investigation resulted in a system, which is called SYNECTICS, for the conscious use of metaphor in problem-solving and hypothesis-formation.[1] In the course of this research it became apparent that the most important element in creative problem-solving was making the familiar strange. Time after time innovative break-throughs depended on new contexts in which to view a problem.

To make the familiar strange is to distort, invert or transpose the traditional ways of looking at, and responding to, the secure and familiar world. It results in achieving a new look at the same old world. In the familiar world objects are always right side up; the child who bends and peers at the world from between his legs is experimenting with the familiar made strange. The tree is familiarly seen as a collection of solids in an otherwise empty space; but a sculptor may consciously invert his world and see the tree as a series of voids or holes carved within the solid block of the air.

Owen Barfield quotes a South Sea Islander's pidgin-English description of a three-masted screw steamer with two funnels: "Thlee-pieces bamboo, two pieces puff-puff, walk-along inside, no-can-see."[2] In our terms, the concepts which describe the steamship are firmly established in the realm of the familiar. The familiar Western concept of steamship is here juxtaposed with the strange, pidgin-English version. Barfield says: "Now when I read the words, 'Thlee-pieces bamboo, two pieces puff-puff, walk-along inside, no-can-see', I am for a moment transported into a totally different kind of consciousness. I see the steamer, not from my own eyes, but through the eyes of a primitive South Sea Islander. His experience, his meaning is quite different from mine, for it is the product of different concepts. This he reveals by his choice of words: and the result is that, for a moment, I shed Western civilization like an old garment and behold my steamer in a new and strange light."[3] The steamer seen by the Western mind in this light is reconstituted and presented as alive and malleable to the imagination.

The attempt to make the familiar strange involves several different methods of achieving an intentionally naive or apparently "out-of-focus" look at some aspect of the known world. This look can transpose both our usual way of perceiving and our usual expectations about how we or the world will behave.

In art and literature the role of metaphor for seeing the world in a new way (for making the familiar strange) has long been recognized. SYNECTICS research, however, has been directed toward the conscious use of metaphor as a means of generating innovations in science. This research has identified three mechanisms, each metaphorical in character, for making the familiar strange:
1) Personal Analogy; 2) Direct Analogy; 3) Symbolic Analogy.

Personal Analogy is essentially anthropomorphic, involving an individual's empathic identification with the inanimate elements of a problem. A chemist, to make the familiar strange to himself, may personally identify with the molecules in action. He is empathically pushed and pulled by the

•
Based on material from a book now in preparation, entitled *The Metaphorical Way of Knowing*, to be published by Harper and Row, New York.

molecular forces. He transcends the rigid formulas that govern the phenomenology. He viscerally feels what it means to be a molecule. He develops strange and new visual images which grow out of the identification process. These new images then constitute making the familiar constructively strange for him. Thus, Kekulé, in attempting to solve the riddle of the molecular construct of benzene, developed a visual image of the molecules being set in the pattern of a snake swallowing his tail. This image led to a breakthrough in chemistry, to the notion of a ring of carbon atoms rather than a linear chain.[4]

Direct Analogy is the conscious comparison of parallel or nearly parallel facts. It requires searching one's experience and knowledge for an image that is like or has some relationship with the subject at hand. Hadamard points out: "Biology may be a most useful study even for mathematicians, as hidden but eventually fruitful analogies may appear between processes in both kinds of study."[5]

Symbolic Analogy is a highly compressed, almost poetic statement of a problem-as-understood. Since this metaphorical mechanism was not operationally defined at the time of the experiment discussed in this paper, it will not be treated here.

During the last five years, the metaphorical procedure for problem-solving has lead to increased success. This success has been the result of making the metaphor-formation more and more operational. Four years ago, the author was invited to initiate experiments at Harvard University in the use of metaphor for solving technical problems. Participants in this two-year experiment included some members of the faculty, a group of Junior Fellows and four groups of freshmen.

This paper is a report of the experiments with freshmen. These freshmen were drawn primarily from students intending to major in the sciences. They met in seminar groups of six, led by the author the first year and assisted by student instructors the second year.

In the early meetings of these seminar groups, students were taught the SYNECTICS technique for using the three forms of analogy described above. Students drilled and practiced Personal Analogy and Direct Analogy, and did the best they could with what was then an ambiguous form of Symbolic Analogy. They were then given real-life technological problems to solve, problems which required innovative solutions. Students were aware that they were participating with the author in a primitive experiment in education. Special meetings were held to criticize the experiment, with the aim of increasing its effectiveness. In the second half of the second year, the students had developed confidence. The process of making the familiar strange through the conscious use of metaphorical images led to new contexts in which to view problems. These new contexts became the basis for innovative solutions and hypotheses. This is what the freshmen learned to do in the face of such straightforward but difficult problems as: Invent a wheel chair that will go upstairs; Design a non-fogging bathroom mirror; Build an anchor which will have more holding power per pound of weight than anything available.

Students now wanted to try using their metaphorical facility, not only to solve problems inventively, but to develop their "private" metaphors for the principles of science they were studying in their regular courses. In the formal science courses, students were being taught the facts of science, but they did not, for the most part, have a depth of understanding. Some students were able to get correct answers, but still felt abstracted and separated from an intuitive grasp of the phenomenology. Other students said that they were inhibited from getting the correct answer by an anxiety about "what was really going on" in the phenomenology. One student stated that he wanted "to make a friend of" the root elements of science; that he was searching for "a personal relationship" with these roots. Another student argued that he would prefer to accept on faith the textbook truths. He feared that while he was developing an intuitive, "guts" understanding, his regular course work might suffer; but even he was eager to experiment with the metaphorical way of knowing "just to see what happened". His opinion was countered by the majority of the seminar members who believed that it was possible to become so proficient in the use of metaphor that ultimately their learning process would be accelerated. A few students said that if they could not begin to understand science in their own personal terms that they would prefer to major in an area of study where each could contribute to his own comprehension, according to his discrete personality.

Since a majority of the students were excited about the prospect, the author gave them the assignment of applying metaphor to "knowing", to the area of making the strange familiar. "Making the familiar strange" through metaphor had led to new contexts in which invention became possible; hopefully, "making the strange familiar" would lead to an intuitive grasp of the facts of science. Freshmen students were asked to construct their own nonrational metaphorical framework by which to understand highly quantified superrational textbook science.

The following are three examples which have been selected on the basis of technological simplicity from the total sample of the students' written assignments:

Problem: The H-X(x-halogen) bond is more polar than in any of the other hydrogen halides. Why then is HF least ionized in aqueous solution?

Student's solution: After an hour of battling out this and related questions with a section man who couldn't make me understand, I decided to attempt the metaphorical approach.

The bond in every hydrogen halide is a polar covalent one. It was stated axiomatically that hydrogen will not give up its one electron to form a completely ionic bond. What puzzled me was that a completely polar, or ionic bond, such as in sodium fluoride, ionized or dissociated very readily in aqueous solution. . . . So I began with a direct analogy. [Students sometimes confuse their facts, but the variety of examples included here have been chosen to give the reader a true sense of the experiment.]

I imagined two cotton bird bodies, one heavier than the other. Around each of the two fluffy spheres was loosely wound a few fibers of long-staple cotton. I imagined them to have been oppositely charged by some lucite rod and cat's fur action within this sort of light cocoon, and floating around in space, encountering water molecules of similar consistency. NaF molecules would only be held by their opposite charges, since they shared none of these strands (electrons or covalent bonding), and would dissociate. Now the number of strands holding H-halogen molecules together is always the same, but the larger the molecule of halogen, (a) the more likely

> that it will be "hit" and knocked free and (b) the more inertia and momentum it will gain, and thus have more power to break away from the hydrogen ion. It stands to reason that two pea-sized objects wound around with four strands of cotton are less likely to separate than two basketballs wound around with the same number of strands. The length of cotton fibers ultimately relates to an appreciation of the universal gravitation law.

The student's hypothesis about the polarity of hydrogen halides derives from his Direct Analogy of the cotton bird bodies. This student had been able to get the right answer; but he was disturbed about his lack of understanding. The student said, "I can never make this science my own . . . my friend, until I grasp it in terms of my own way of seeing it."

Another example from a different realm of science reflects the same style of learning:

> *Problem:* Given the definition that a function T; V→V (i.e. with domain V and range V) is nonsingular if and only if the image of T equals V, show that T is nonsingular if and only if T has an inverse.
>
> *Student's solution:* T maps V onto *itself*—introversion, self-absorption come to mind. Sounds like a personal situation; so I think I'll try Personal Analogy. I'll be V. Now the definition reads, T maps me onto myself and is nonsingular if my image under T is myself. With this image idea and starting with myself and ending up with myself, it sounds as if this T is a mirror. . . . Well, that's it! I'm V, and I'm looking in the mirror, T, and what do I see? Me! T may have reversed my image from left to right, but I'm all there. My image equals myself. But what does that prove? Isn't it always true? Don't you always see your own image? If I saw someone else in the mirror, then T wouldn't be going from V to V, it would be going from V to W—but wait a minute. Suppose my image was missing an arm. Then my image would be a subset of myself, but not equal. It wouldn't have all the parts that I have. So, that's the definition then—I look in the mirror, and if my image is complete, then it's a nonsingular mirror; but if any part of me is missing, then the deal's off. Now, I've got to show that my image in the mirror will be complete if and only if T has an inverse. That means that my image can look back out at me. But what if my mirror gave a one-armed image? That image could look at his inverse mirror and his reflection would have two arms. How can he get two arms out of one? He can't! That's it! If T is a function for every x, you can get only y, or else it's not a function, only a relation. In order for that image to look back at me, he's got to be complete; if he only has one arm, he can't see a thing. So if there does exist an inverse function, then my image has to be complete; and so the mirror T must be nonsingular. If T is not a function, then my image is missing some part of his anatomy, and the mirror is nonsingular.

The above distinction between complete images and images with parts missing is obviously the same whether or not T is one-to-one, i.e., every part of my body had one but no more than one corresponding part in the mirror. So:

Definition: T: V→V is nonsingular if in T = V
Show: T is nonsingular if T has an inverse.

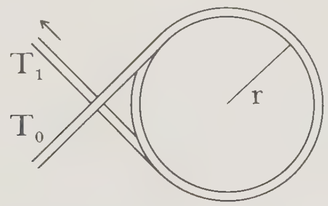
1) T^{-1} exists. Then T must be one-to-one, V→V.
Then T(V) = V, and T is nonsingular.

2) T^{-1} does not exist. T is not one-to-one, T(V) cannot equal V. T is not nonsingular.

The above assignment shows the process of going from a Personal Analogy to a visual image and then speculating with the visual image itself; all this resulting in a new and personally discovered context in which to make the strange familiar.

The next example may be the clearest use of metaphor because the subject matter of the problem more easily lends itself to immediate personal involvement with the elements:

Problem: A device called a capstan is often used to help support a large load with a small force. As shown in the diagram, the rope which is stretched by a tension T_0 is wrapped around the drum. A smaller tension T_1 applied to the other end of the rope keeps the rope from slipping. The coefficient of friction is u and the radius of the drum is r.
Find the relation between T_1 and T_0.

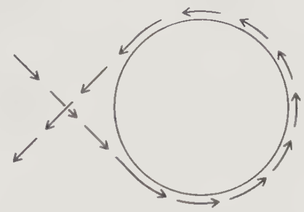


Student's solution: We have a situation where forces are acting, but are not apparent. There is no movement. Then how do you know there are forces?

If I am part of the rope, holding it together, I am stretched. Now say I am in the rope, which is a "stretch field", but I am not part of the rope; I am swimming in it. Then I must work to move through the rope. I must in fact climb the rope and stretch myself at the same time.

But I am in this rope now, which is like an elastic fluid. How can this rope stretch me and move me at the same time?

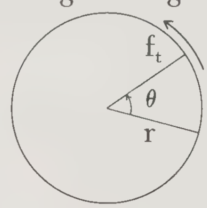
Suppose it is a one-dimensional vacuum with successive compartments, each of which has a higher vacuum than the one before. This suggests a particle accelerator. There is a force-field created in the particle accelerator that cannot be seen. A measure of the field is the work done on a particle moving through it.



Take the rope as a particle accelerator. There is a centripetal force acting on the particle at all times. A stipulation of the problem is that the accelerator, the rope, must not be accelerated by the force which it transmits. The field strength at any point is equal then to the frictional force applied to keep the accelerator from accelerating. But we are given the relation between the two:

$f_t = uf_c$ where $f_t =$ tangential force
$f_c =$ centripetal force

Now imagine that the particle has been accelerated through an angle θ.



Then the work done on the particle is:

$$W_p = \int_{S=o}^{S=r\theta_o} f_t\,(S)\,ds$$

The student then evaluated the kinetic energy that his "particle" developed as a result of the "work" done on it as in the accelerator analogy.

But kinetic energy $= \frac{1}{2}mv^2 = w$ where v is the velocity of the particle at that point.

From here the student proceeded analytically in traditional fashion. His solution was not exactly correct, but the conceptual image of particular kinetic energy furnished the student with an insight from which he could hypothesize. Later he brought his analytical training to bear.

In the above assignment, the student moved from a series of Personal Analogies to the Direct Analogy and visual image of the rope as a particle accelerator. This visual image then developed into the understanding which resulted in the hypothesis.

In the course of this experiment, it was suggested that students check with their professors as to the pertinence of the images and metaphors. In some situations the professor agreed with the relevance of the imagery. In other instances, the professor said that the visual images and resulting hypotheses did not describe the phenomenology. But, in spite of this lack of relevance, the dialogue between student and professor led away from the "correct answer" attitude toward shifting the student's images to better conform to the facts. Sometimes, a professor would sanction the relevance of a student's images, but preferred his own. This constructive disagreement diverged from the stilted elements of science toward a discussion of aesthetic values, from a question of relevance to a question of personal preference. In all cases students began to sense that they were getting at the heart of the organic development of science. In general, students were surprised that any professor would be interested in the images by which they understood the material (as much so as in the correct answers). Through the metaphorical way of knowing they began to have a new and friendly way of viewing a world that previously had been a priori and external.

Perhaps the greatest danger in the teaching of science is to present students with a *fait accompli* universe. It is a didactic tradition that undergraduate students must accept the phenomenological universe as described by someone with special knowledge, i.e. the teacher. The teacher is saying to students that they must surrender to his rules or they can't play in his backyard. By the time a student has clerked his way through his undergraduate work in a science, it may be impossible for him to tolerate the ambiguity of constructing his own ways of understanding.

An argument can be mounted, of course, against encouraging students to develop their own hypotheses before they are armed with sufficient substantive knowledge. The argument asks the question: "How can intellectually naive freshmen invent meaningful metaphor-analogies for theories that are brand-new to them?" The point of this paper is that freshmen *can* produce meaningful metaphorical images and that encouraging this form of speculation may lead students toward the habit of constructive hypothesis formation.

Another argument against the metaphorical way of knowing could be that the conscious process of forming analogical material might hold back students who are gifted abstractionists and facile generalizers. However, is it not possible that these gifted ones are already successfully operating on an unconsciously learned metaphorical basis? Furthermore, the use of metaphor in hypothesis-formation can be learned, and even students who have been functioning metaphorically without being aware of it seem to increase their capacity after some practice in generating metaphors.

As can be seen from the three examples, certain sciences lend themselves to discussion of personalized visual image-making. For instance, the capstan in the physics problem is a real thing, as is the rope around it. You can feel and touch a capstan. It required a minimum of psychological strain to identify with the rope and develop visual images on which to base a more coherent use of knowledge.

The function problem, on the other hand, shows a greater level of abstraction. However, the student, through the conscious use of metaphor and analogy, was able to create the visual image of the mirror and bring back this highly concrete image to the abstraction of the problem.

In the halogen bond problem there is a considerable leap from the axioms of the chemical situation to the analogue of the cotton bird bodies. However, it cannot be said this leap was accidental, because the student had been practicing this kind of analogical jump before he approached his exercise.

Good teaching has always made ingenious use of metaphor and analogy to help students visualize the internal workings of substantive material. It is the purpose of this paper to suggest the possibility of teachers encouraging students to develop their own metaphorical-visual process of understanding. Of course, there are some students who continually strive for immediate certainty. These students have learned that education is a game where their success is measured by ability to produce the correct answer. This kind of student will be uncomfortable when asked to develop his own images. Probably his reason for going into science is his dependence on the chromium exactness which he equates with scientific knowledge. In the course of the experiments with Harvard freshmen, however, it was observed that even these anxious students could construct their own images. The technique was to drill them till they became highly efficient in the psychological mechanisms for making analogies and metaphors. Once the process of metaphor-formation became part of their thinking, they then dared to extend this process to include personal ways of understanding facts.

The very concreteness of the students' own visual images reinforced their growing confidence in the process:

> "I imagined two cotton bird bodies . . . two fluffy spheres . . . floating around in space. . . ."
>
> ". . . I map me into myself. . . . . I'm looking in a mirror and what do I see? . . . I'm all there. My image equals myself. . . ."
>
> "I am in this rope now . . . I am swimming in it. I must work to move through the rope. I must in fact climb the rope and stretch myself at the same time. . . ."

These sample statements reflect the highest level of concreteness. They are not derived, external notions, but are simple, internally conceived images.

Our experiments have shown that it is not enough for a teacher simply to tell his class to go out and make up their own images. This kind of action will be viewed by students as a threatening irrelevance unless the teacher can give examples from the history of science showing the constructive use of metaphor and mental image. When a student begins to get a sense of the image-formation that underlies great science, he becomes motivated to emulate and practice this element of hypothesis-formation. For instance, Einstein said: "The physical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be 'voluntarily' reproduced and combined . . . this combinatory play seems to be the essential feature in productive thought. . . . The above elements are, in my case, of visual and some of muscular type."[6]

It is the purpose of early experimental data to lead to a working hypothesis which can act as the background for future research. It would be impious for the author, after so short an experiment and so small a sample, to draw more than preliminary implications. On the basis of research that has been implemented so far, however, the author can conclude only that students can be taught the conscious use of metaphor and that these metaphors can lead to visual images for an intuitive, personalized grasp of science.

1. Gordon, W. J. J., *Synectics: The Development of Creative Capacity,* New York, Harper and Row (1961).
2. Barfield, Owen, *Poetic Diction,* London, Faber and Faber (1957), p. 49.
3. *Ibid.*
4. Libby, Walter, "The Scientific Imagination", in *Scientific Monthly* (XV:1922) pp. 263–270.
5. Hadamard, Jacques, *The Psychology of Invention in the Mathematical Field,* Princeton, Princeton University Press (1945), pp. 142–143.
6. Reiser, A., *Albert Einstein,* London, Thornton Butterworth Ltd. (1931), p. 116.

JOHANNES ITTEN

THE FOUNDATION COURSE AT THE BAUHAUS[•]

I first began to study art in 1910, in Geneva, but as in all art academies at the time, the instruction methods there were still medieval. The professors showed their students how they themselves worked and the students tried to copy them. Those who imitated their teachers best were regarded as the prize pupils. No art academy presented an objective introduction to the basic formal and coloristic means of expression and the problems of creation, nor did they attempt to encourage students as original personalities. Only Adolf Hölzel, at the Stuttgart Academy, had begun to teach composition methods and color principles systematically. When I heard about this, in 1913, I went to Stuttgart to attend his lectures. Hölzel, I found, was a stimulating and open-minded teacher, and gathered around him was a group of young, hard-working students, among them Oskar Schlemmer, Willy Baumeister and Ida Kerkovius. With them I could discuss Cubism and Futurism. In addition to my creative work I soon began to teach.

In 1916, at the suggestion of one of my pupils, I moved from Stuttgart to Vienna to establish a school of art and develop my own teaching methods. Among these was the study of structural themes and subjective forms. Also, the study of polar contrasts, and exercises to relax the student and heighten his concentration, proved successful. I found creative automatism to be one of the most important problems in art education. I myself worked on geometric abstract paintings.

In the spring of 1919, after the end of World War I, Alma Mahler-Gropius who was very much interested in my painting and my educational theories, invited me to spend a week-end in the Semmering and introduced me to her husband, Walter Gropius. While talking about the Bauhaus, which Gropius had just then established in Weimar, Alma Gropius said to her husband: "If you want to succeed with your idea of the Bauhaus, you had better get Itten."

Gropius subsequently visited me in Vienna to see my abstract paintings and the work of my students. When he left he said: "I don't understand your painting or the work of your students, but if you want to come to Weimar, I would be delighted."

I was particularly attracted by the fine classrooms and workshops and the fact that the Bauhaus was still empty, so that anything new could be erected without major demolition first. Two new teachers appointed by Gropius, Gerhard Marks and Lyonel Feininger, had already arrived.

As yet, little was known about the objectives and approach of the Bauhaus; the only publicized statement was a manifesto by Walter Gropius which said: "The ultimate objective of all plastic art is building. . . . Architects, sculptors, painters, we all have to return to craft. . . . There is no basic difference between artist and artisan; the artist is merely an intensification of the craftsman. . . . A foundation of craftsmanship is indispensable for the artist. It is the prime source of creative productivity."

Since the basic goal of my efforts to teach art had always been the development of the creative personality, fourteen of my students followed me from Vienna to Weimar and formed the nucleus of the first course at the Bauhaus.

Students from all parts of the country, young and old, and with rather varied educational backgrounds had applied for the winter semester of 1919–20. Most of them had attended the usual arts and crafts schools and art academies. The samples of their work submitted with their applications showed little individuality. Consequently, it was difficult to judge the talent or character of the applicants. I suggested to Walter Gropius that anyone showing artistic inclinations should be admitted provisionally for one term.

We called this provisional semester the *Vorkurs* or foundation course. Thus the expression *Vorkurs* originally signified neither a special curriculum nor a novel teaching method. I took over the direction of this foundation course and was faced with three specific tasks: to ascertain the creative ability of the student, to help with his choice of a vocation, and to teach him the basic creative approaches for his future career as an artist.

After successfully passing the foundation course, a student would learn a craft in the workshops of the Bauhaus, and at the same time receive a basic training in design for a future collaboration with industry.

The foundation course had been planned as a semester of intensive work, but the political and economic instability of the post-war period proved rather detrimental to our work. Many students were destitute and

[•] The author has published a detailed account of this course: *Mein Vorkurs am Bauhaus. Gestaltung- und Formenlehre.* Otto Maier, Ravensburg; English language edition, *Design and Form. The Basic Course at the Bauhaus,* Reinhold, New York, Thames and Hudson, London, 1964.

hungered their way into an uncertain future. We had sufficient studio space, but there was no heat, so I only taught one morning a week. The rest of the time the students worked by themselves on assigned tasks and individual problems, without supervision, in their own quarters. Actually, this "being on one's own" was very important for self-discovery. Individual inner growth cannot be achieved when students are stuffed with outside knowledge and have no time for introspection.

My teaching was designed to guide the student in acquiring the means of artistic expression by appealing to his individual talents and so develop an atmosphere of creativity in which original work became possible. Each student was expected to realize "himself", his original works had to be "genuine". Thus he gradually became self-confident and more conscious of himself. He could find his vocation, unless obstinacy and ambition threatened his awakening sensibilities. This choice of a vocation was facilitated considerably by tests with patterns and materials. The student soon found out which materials appealed to him, whether wood, metal, glass, textiles, stones or clay stimulated him to creative activity.

It takes various aptitudes and energies to bring about creative achievements. To receive new ideas requires devotion and preparedness, tranquillity and self-confidence. To realize creative ideas through the expressive means of art takes sound physical, sensual, spiritual and intellectual powers and qualities. This insight determined the goal and methods of my teaching.

At the Bauhaus, I worked to build up the entire person as a creative being. This "program" I expounded upon constantly at the meetings of the teachers' council.

The terrible losses and horrible events of World War I and a close study of Spengler's *Decline of the West* made me realize that we had reached a crucial point in our scientific-technological civilization. For me, it was not enough to embrace the slogans "return to craft" or "art and technology, hand in hand". I studied Eastern philosophy, delved into Persian Mazdaism and Indian yoga teachings, and compared them with early Christianity. I reached the conclusion that we must counterbalance our externally oriented scientific research and technological speculation with inner-directed thought and practice. I searched for something, for myself and my work, on which a new way of life could be based.

A teacher who had arrived at the Bauhaus after me, Georg Muche, had reached similar conclusions in his thinking after his experiences in the war, and we established a friendly collaboration. Inevitably, in my feverish searching and practicing, I made mistakes, since I myself then lacked the great teacher who could have guided me through the turmoil of that period.

How did I realize my ideas about art education at the Bauhaus?

At the beginning of each instruction period I gave the class exercises in relaxation, breathing, and concentration to achieve a state of spiritual and physical readiness which is conducive to intensive work. The training of the body as an instrument of the spirit is essential to the creative artist. How can his hand express in a line a specific emotion if hand and arm are strained? The finger, the hand, the arm, the entire body have to be trained by relaxation, strengthening and sensitizing. The breathing of the student had to be checked and improved. Advice about diet and hygiene followed. After this introduction, a harmonic alertness permeated the class and I was able to start working out problems and exercises concerning the means of artistic expression.

Forms and colors were discussed and presented in any number of polar contrasts. These contrasts can be presented as intellectual concepts: big-small, long-short, wide-narrow, thick-thin, light-dark, straight-curved, pointed-blunt, much-little, hard-soft, smooth-rough, light-heavy, transparent-opaque, steady-intermittent; there are also the seven color contrasts and the four directions in space. The students had to present these various contrasts, separately and in combinations, in a manner that allowed our senses to perceive them convincingly. I explained three different approaches to form and color: as qualities and quantities that can be recognized by our senses, grasped intellectually, and felt emotionally.

All artistic effects are based on the creation of contrasts. One of my main points was to present these contrasts properly so that specific effects could be achieved. In Weimar, exercises with patterns and textures proved particularly effective. We not only studied their contrasts—smooth-rough, hard-soft, light-heavy—visually but also explored them with our fingertips. I thereby expanded and improved the sense of touch.

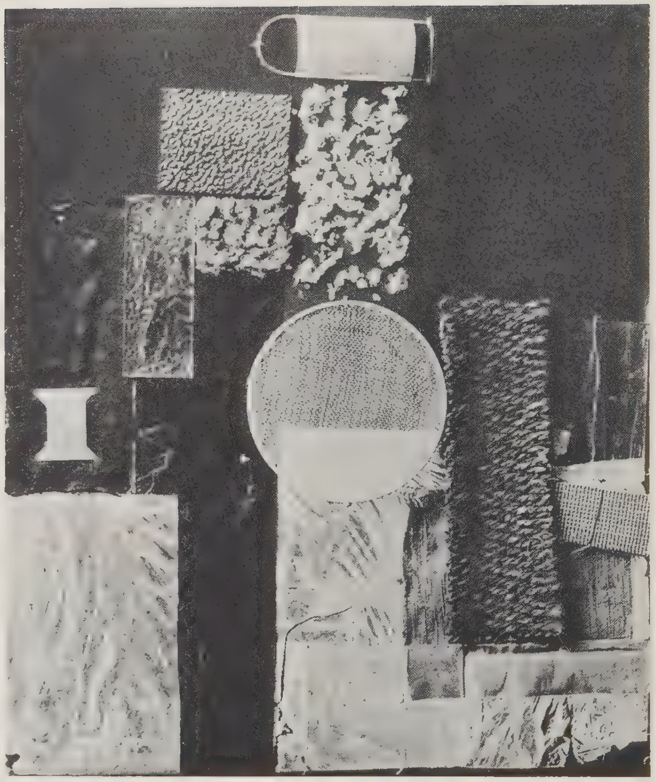
We arranged various materials in long chromatic rows. After a few hours of practice the sense of touch improved astoundingly. We also created texture compositions of contrasting natural materials (Figs. 1–4).

We arrived at fantastic shapes which were then completely novel in effect. While solving these problems the students developed a truly creative fervor. To deepen and control the experience, students had to contemplate, touch, and draw these textures until they knew them by heart and could reproduce them out of their inner perception, without the natural model (Figs. 5–8). Such study of nature, which begins with exact observation and experience, and proceeds to objectification based on inner perception, deepens the sensual realization, controls it, heightens the sensibility and, finally, provides the artist with a reservoir of "inner forms".

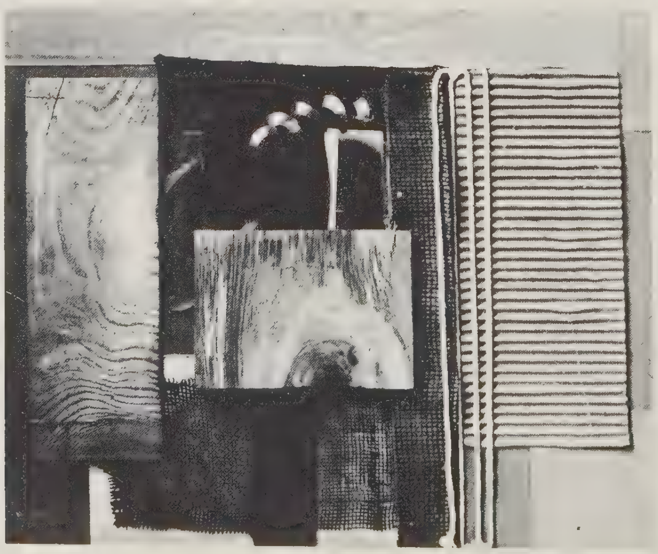
The experience of these forms, which reveal themselves to us only when we understand their essential character and know it by heart, results in a tremendous expansion of our experiential range and form consciousness (Figs. 11–13).

This contemplative condition produced not only experienced natural structures, as in Fig. 9, but also purely inventive forms without any relation to natural objects, as in Fig. 10.

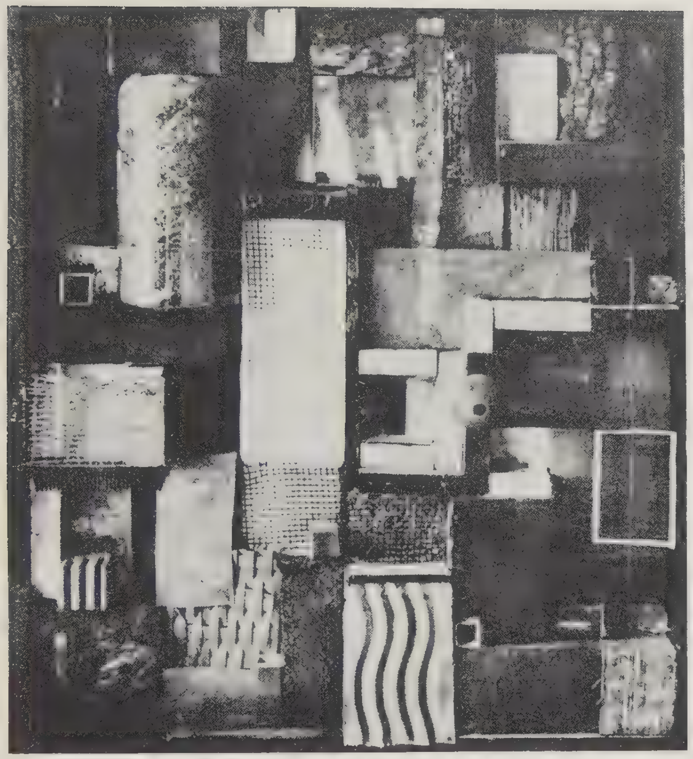
The creation of such abstract forms becomes more impressive the richer the inner world of the artist is in forms and colors. Through these exercises the students find their own subjective forms and formulations which provide the precious and genuine basis of original, individual work. Nature appears in totally new effects and the micro-world revealed by science and technology acquires an important new aspect.



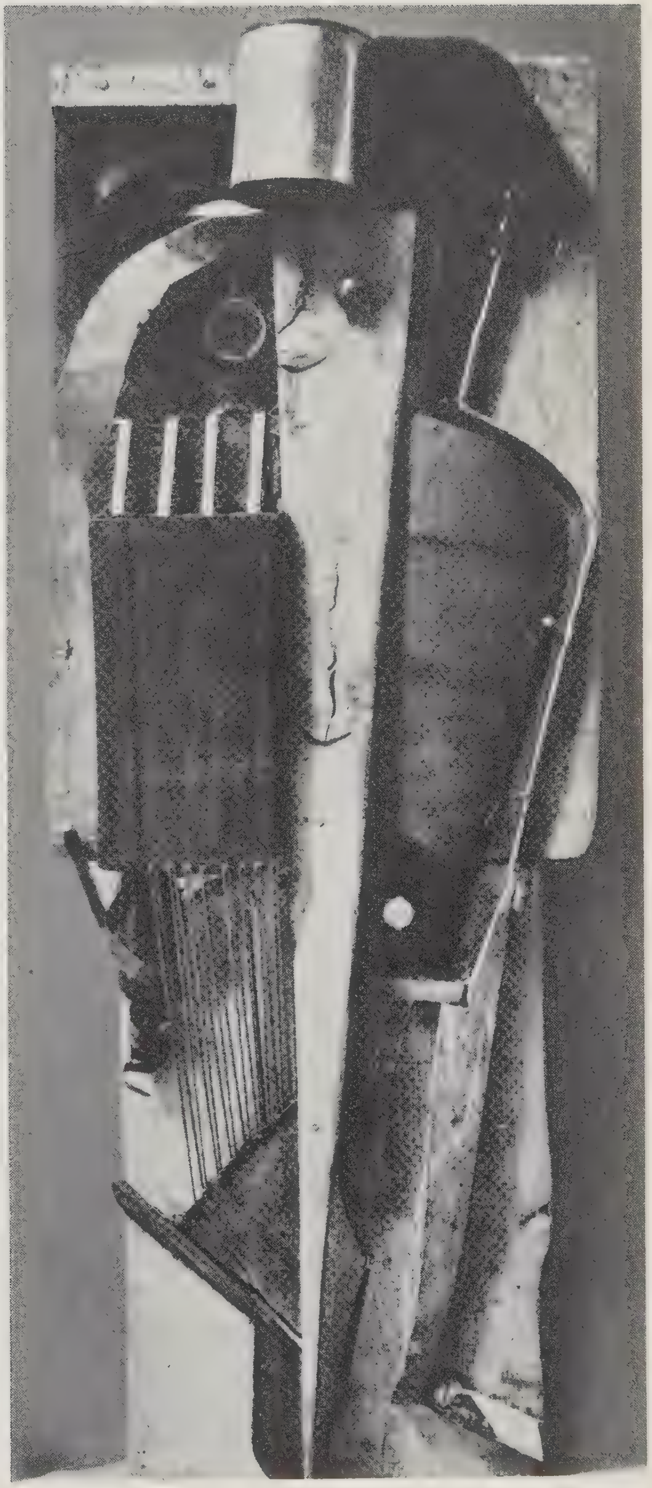
1



2



3

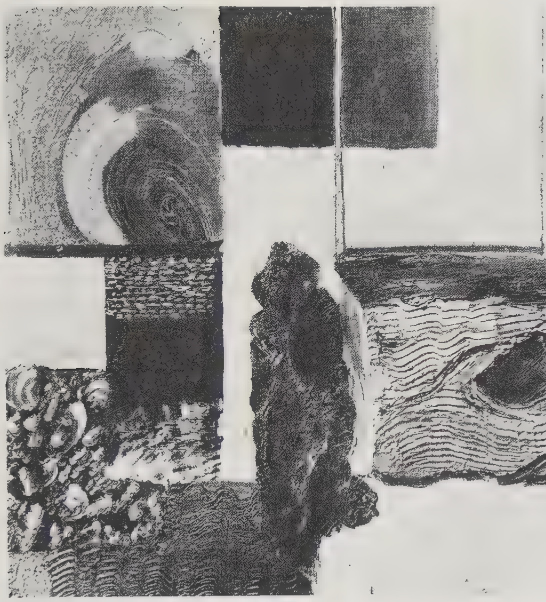


4

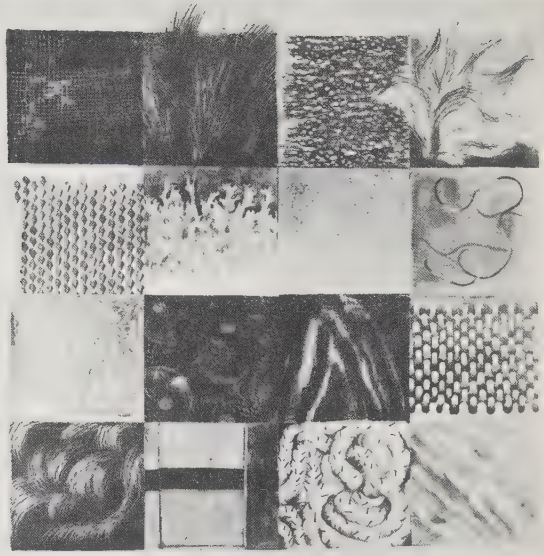
5

6

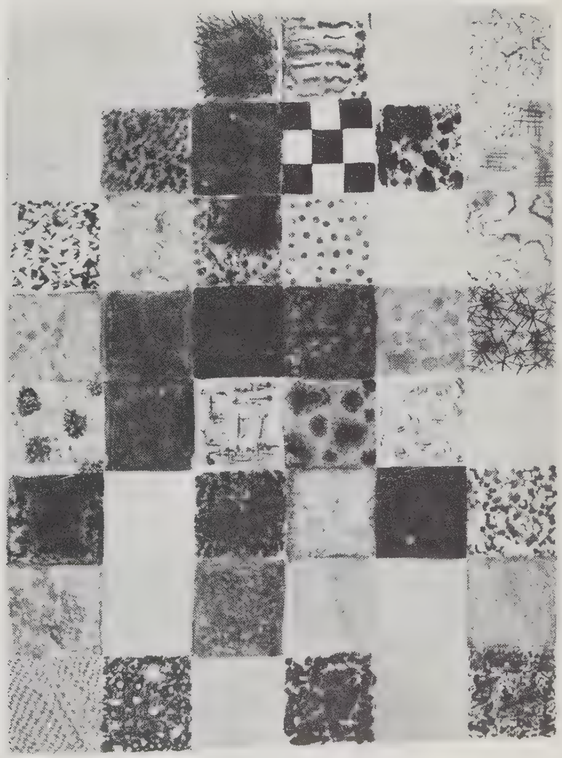
7



8



9



10

11

12

13

Aside from training the eye and the sense of touch, and deepening the perceptive faculties, it is important to expand and clarify artistic thinking. Without the ability to think clearly no artistic creation unimpaired by superfluous clutter is possible.

We therefore worked on the problems of elementary geometric form-characteristics. We studied circles, squares, triangles and their derivatives, as well as lines, planes, objects and stress points, directions in space, and proportions. All studies designed to improve constructive thinking were also subjected to tests by perception. I will here illustrate this with an example concerning proportions.

One can develop lines subdivided by proportionate numbers. The sequence of these numbers can be varied. One can set up proportions like 1:2:4:8:16:32 or 1:3:9:81. The Golden Section and the proportions of the harmonic triangle should be studied. Proportions can be worked out not only with lines but they can be construed and contrasted with planes, squares, triangles, circular planes and volumes.

The student soon learns that proportional contrasts can achieve effects which no longer correspond to the reality of numbers. A distance can be made to look longer than it actually is by contrasting it with a short form. These simultaneous changes in proportion are very important. Such effects cannot be measured numerically but can be judged only by perception. Simultaneous effects give proportions the mysterious life which the artist seeks and uses in his works.

Problems of non-objective abstract composition also served to improve the thought process, and at the same time provided new means of expression.

Studies in variation and combination also helped to expand the student's thinking. As a practical experience they are indispensable to conveying the enormous wealth in forms and colors. To introduce the subject, I often used four kitchen matches. These matches, wooden sticks with heads, allow the student to achieve a multitude of new form elements by manipulating them horizontally, vertically, diagonally, by turning, reversing, overlapping, by varying the proportions, by changing light values and color, and by using combinations of these variations.

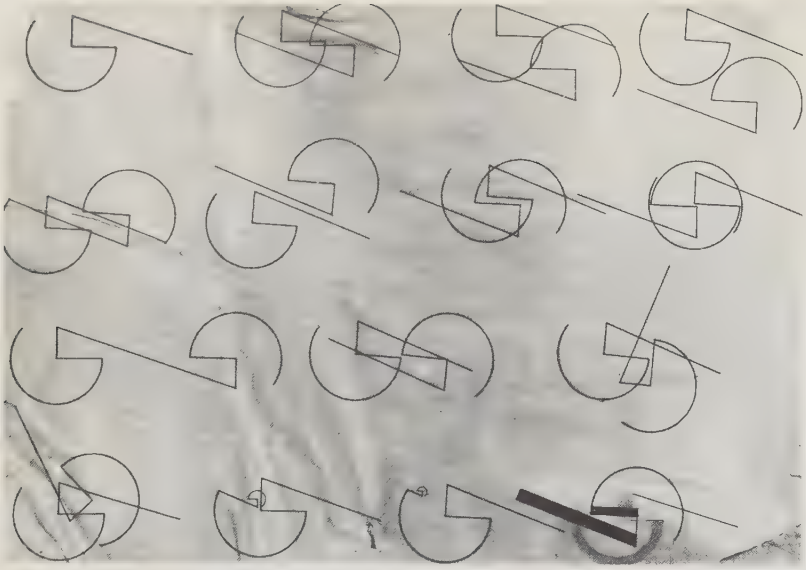
In Figs. 14 and 15, variations and combinations have been developed from a line motif constructed of circular, square and triangular elements. Each of these solutions must be thought out, and represent a clear form-figure. The creation of a work of art often requires that the creative potential has at its disposition a multitude of possibilities to arrive at the simplest and clearest formulation. Fig. 16 is the final solution out of a series of studies like those shown in Figs. 14 and 15.

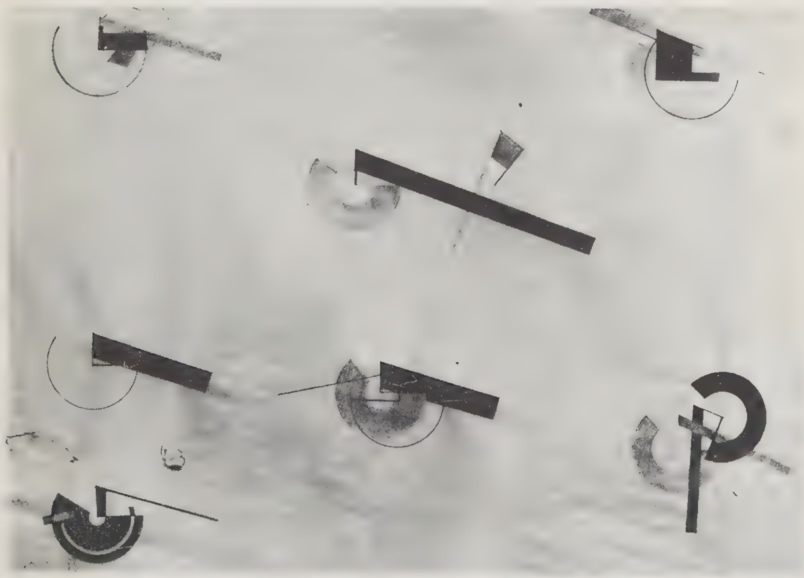
To awaken an understanding of formal unity in the student we made compositions with the characteristics of a square, a triangle or a circle and combinations of two or three such forms.

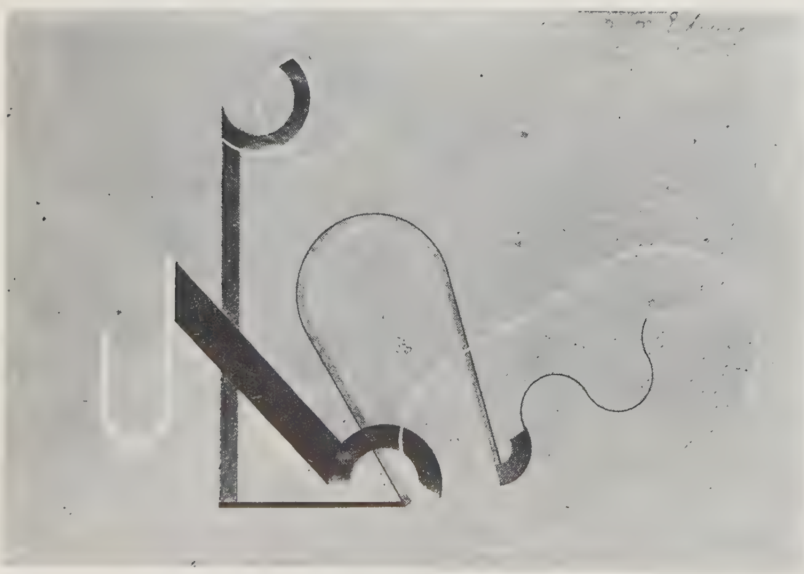
Very important also was the study of plastic forms and their representation. I started out by having the students make clay models of spheres, cubes, pyramids, and cylinders so that they could perceive and experience elementary plastic geometrical forms. Then they had to model compositions within a single specific form. Fig. 17 shows such a composition in terms of a cube—it is by no means an architectural design! Fig. 18 shows the solution of the same problem carved in stone.

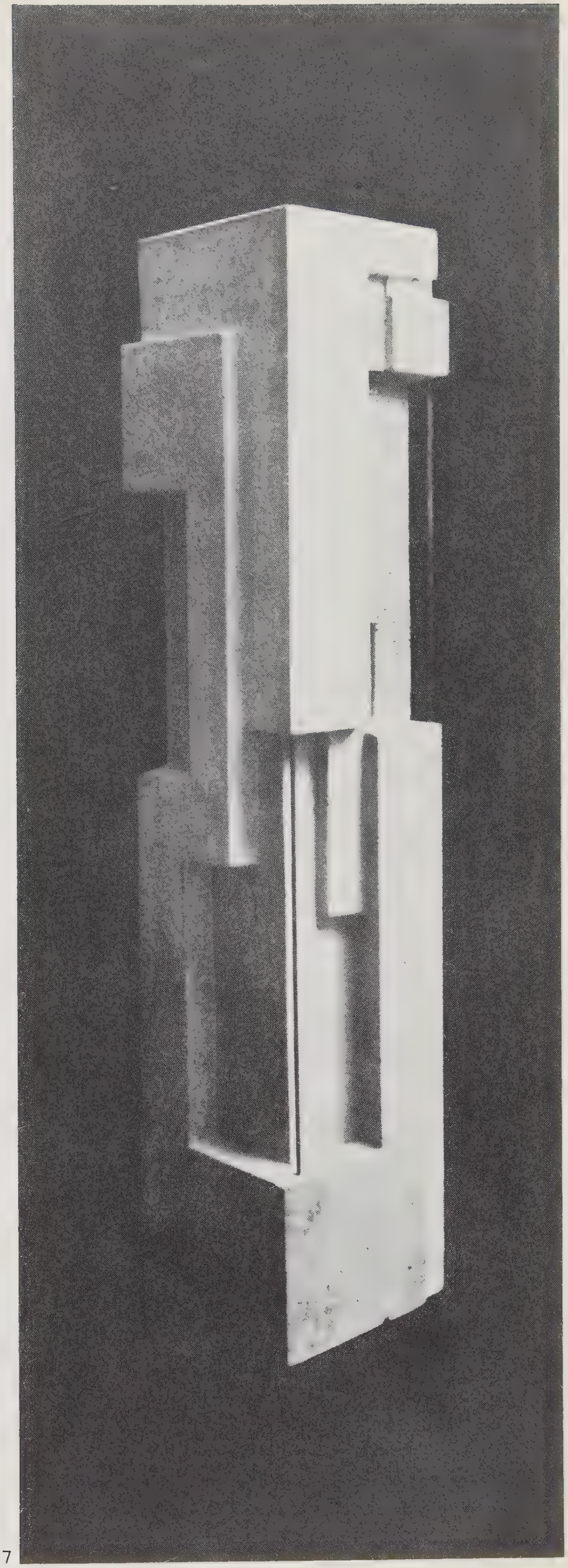
Only after the model exercises did we try to present plastic geometrical forms graphically by imitative light and shadow effects (Fig. 19). As a second exercise we worked out the problems of presenting plastic forms on a picture plane (Fig. 20). In this presentation the naturalistic plastic effect has been dematerialized in favor of the pictorial plane.

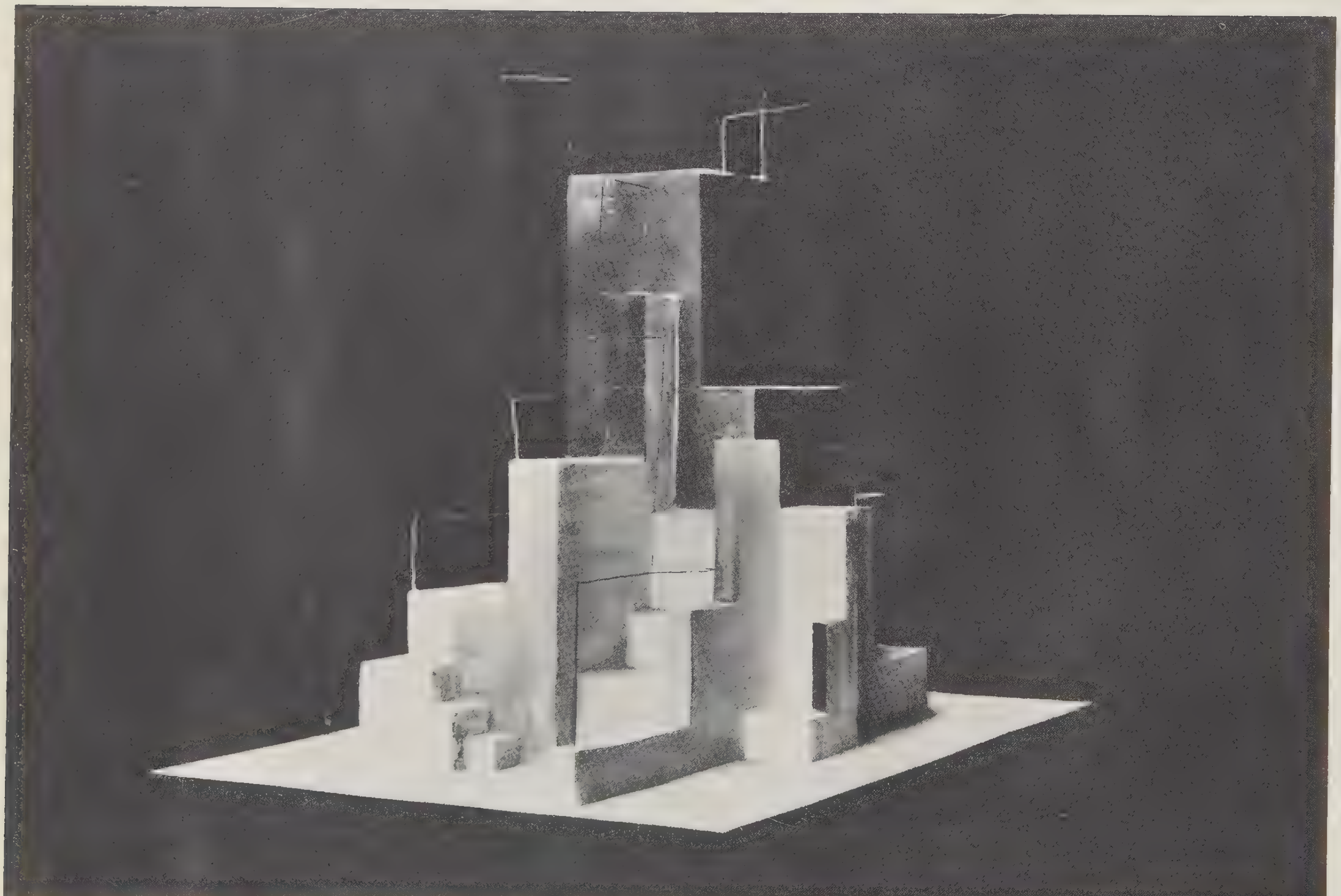
We also had to work out the complicated problem of colors, with their seven contrasts, in a constructive, logical fashion. My book, *The Art of Color* (New York, Reinhold Publishing Corporation, 1961), gives a detailed and comprehensive presentation of my color theory, of which I taught the basics at the Bauhaus.


14

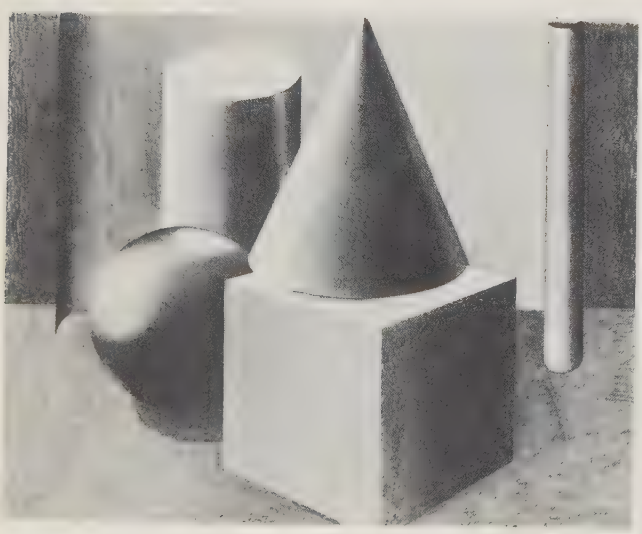

15


16


17



18



19

20

The teacher's most difficult problem is the liberation and deepening of the inner spiritual sense of perception. To conduct exercises in that area one needs a very pliable, labile material which reacts immediately to the slightest motion of the hand. I used India ink brushes and soft charcoal.

Fig. 21 shows line exercises with the brush. Each of these lines comes out right only if it is created with utmost concentration and relaxation. Fig. 22 is a duet of lines drawn simultaneously with both hands. Figure 23 is composed of a line and a dot. Figure 24 shows a perceived form from which the accents were sorted out to find the subjective proportions created by emotion. In another exercise, the students spent half an hour every morning for an entire week in front of a potted fern, studying it by drawing. At the end of the week, the students had to create the fern from memory. The fern, seen in Fig. 25, was freely drawn within twenty minutes. This exercise indicates that images of forms have to be developed clearly so that subjective perceptions can be objectified. Fig. 26 shows a shorthand notation of the perception of a violin. The clearer and more objective the image of a violin is developed in the student's mind and the more freely the motions of hand and arm can follow the inner form image, the more expressive the drawing becomes. The roaring tiger in Fig. 27 has been created out of a pure fantasy image. The success of these studies wholly depends on the student's ability to overcome his intellect and the function of his senses and give himself totally to spontaneous feeling. An inner automatism quite naturally gives a convincing outer form to his feelings.

Access to this automatism can also be found through rhythmic writing exercises which call for the creation of rhythmic forms by uninterrupted motion. But these rhythmic motions have to be more than simply rhythmic motions of the muscles; they have to receive their impulse from the inner rhythm of the heart. Physical, sensual, intellectual-constructive and spiritual-expressive powers are most valuable when they are directed by the creative spiritual center of the heart.


21


22

23

24

25

26

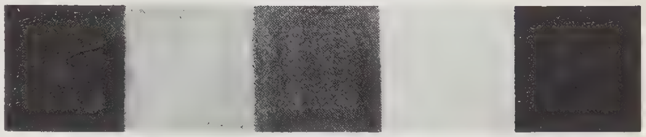
27

Problems of the light-dark contrast were illuminated through the following exercises. Fig. 28 gives a sequence of steadily darkening tone values. At the beginning of this exercise it was obvious that most students could barely distinguish twelve tone values, but after three or four practice sessions the response to tone values became almost twice as good. Fig. 29 shows a five-tone light-dark scale, constructed of equal-sized planes. This very simple exercise in composition was worked out by letting the students compare five or six of their own solutions and decide which one was the best. The best solution by each student was then compared with those of his classmates and the result was always general agreement as to the best solution of the class. This proved to me that each person carries within him the same absolute standard. The same tone-scale exercise is shown in Fig. 30, but with two different contrasts. A contrast in proportion has been added to the light-dark contrast. Fig. 31 shows the same two contrasts but developed in horizontal and vertical directions. These exercises were followed by studies of natural forms rendered on the light-dark scale.

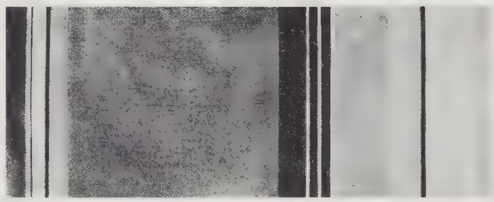
To lead the student out of his own subjective thinking, he had to analyze a painting by an old master who composed in light-dark contrasts. Fig. 32 shows such an analysis of the portrait of the Duchess of Alba by Goya. The imposed geometric division forced the student to work more consciously.

Essential in all these studies are not the objects but the scale character of the tone-value relations, as it was worked out in Fig. 29. A work has artistic value only when such scale values have been achieved.

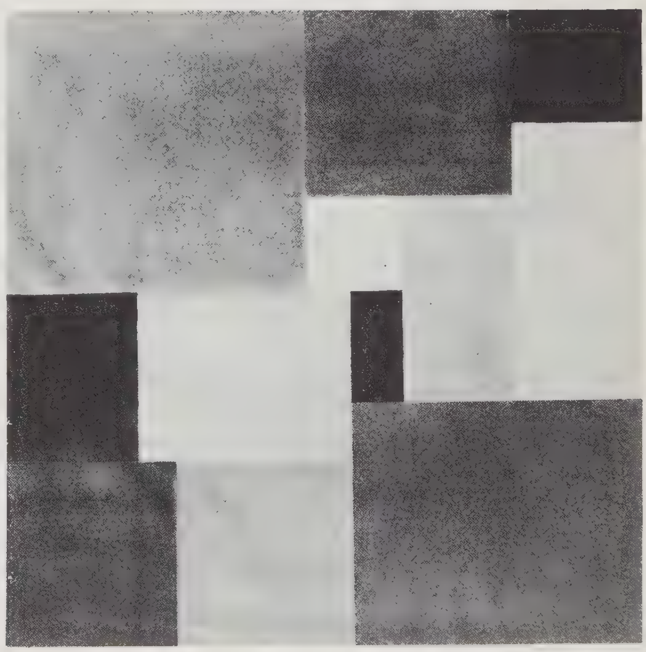
28



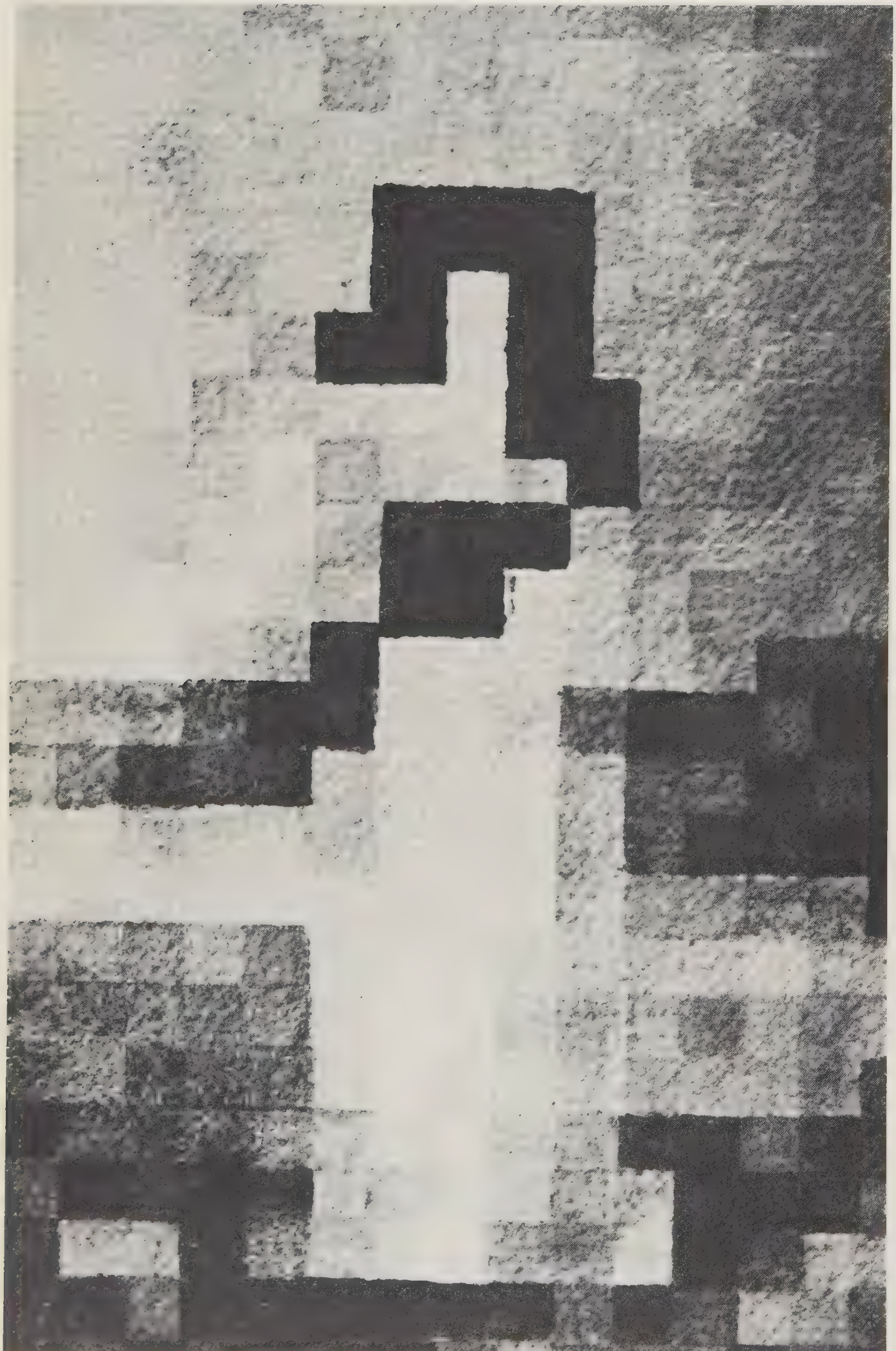
29



30



31



32

After these studies, which essentially are blots, we worked on linear-rhythmic exercises. Fig. 33 demonstrates rhythmic countermovements and revolutions. These exercises were supplemented by analytical studies of old masters. Fig. 34 captures the rhythmic motion-forms of a painting by Mathias Grunewald; it is not an imitative reproduction of a masterwork.

I found time and again that individual students showed markedly different aptitudes for the various subjects I taught. It was easy to pick out those who were particularly gifted in the areas of light-dark, line, rhythm, or construction, and who showed up best in one or several of these areas.

The analytical studies proved valuable in working out different particularities of an important artist, which helped me in expanding the subjective tendencies of a student and gave him greater insight into objective creation.

An alert teacher, who approaches teaching creatively, will find that sometimes a word or a sentence spoken to a student at the right moment will unlock the door to his creative center. The student suddenly arises, gathers himself, and within a few crucial hours, days or weeks, awakens to independent, original accomplishment. At such times, the teacher must be a gentle and protective guardian. The student has to live through these times of individual development all by himself. This condition effects a certain separation and liberation of the student from the teacher. The student turns into an independent being.

Some historians have erroneously described the first Bauhaus years as the romantic period of the Bauhaus. I would call it the universalistic period of the Bauhaus. Today, forty years later, we realize that the Bauhaus was in tune with the general progress of civilization, not only in its formalistic accomplishments but also in its ideological, educational and artistic efforts. At the time, people laughed and made fun of us because we conducted breathing and concentration exercises. Today it is quite normal for people to be interested in Eastern philosophy and to practice yoga.

In the fine arts, we increasingly find individually differentiated work by singular personalities. Thus, with less resistance and more as a matter of course, we are today reaching the objectives which I tried to establish at the Bauhaus as the foundations of a new education.

33

34

DESIGN EDUCATION•

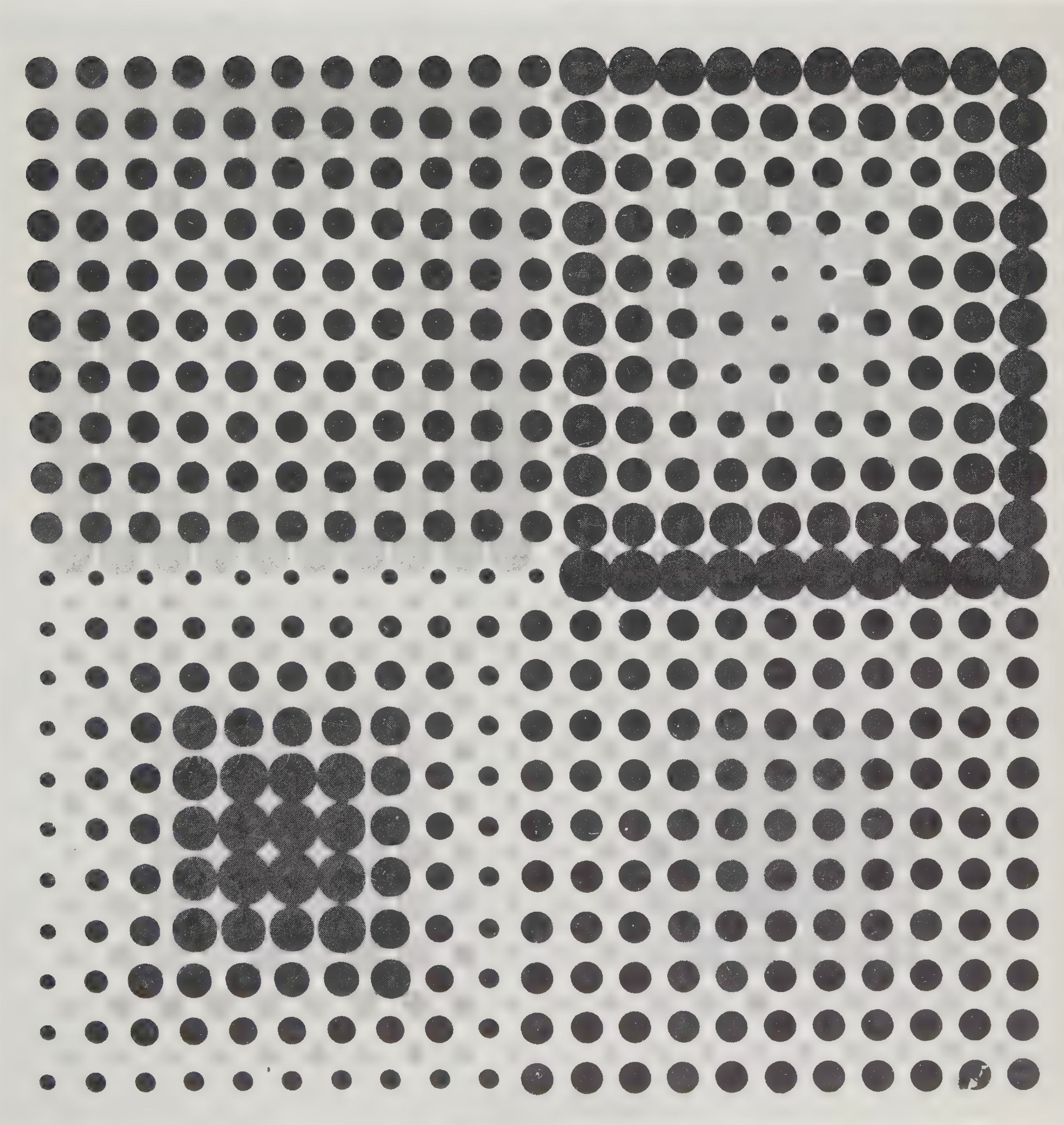
The meaning of the word "design" has been strangely corrupted by general usage. The same is true for the word "education". Thus "design education" is a doubly confused expression. It can be interpreted in very different ways and serve entirely different purposes. Forgetting for the moment all we know or believe we know about design education, forgetting the ideas of the past and the ideas of the present, the ideas of others and our own ideas on this subject, we must start from the very beginning by asking what is design education. That design education be education for design is a tautological definition which says very little. Obviously to really define design education we must first ask what is to be understood by "design."

If we stop to analyze the nature of the products resulting from the human activity we call design —whether these products be scientific, technical, industrial or artistic—we find that all of them represent not only an activity but also a capacity. For the moment, this capacity could be called creative. Probably we are not mistaken in saying that design is creation, or if you prefer, the means of creation par excellence. At least it is evident that design is neither imitation, nor the means of imitation par excellence. Design is always an attempt to break with banality, a manifestation of originality. Indeed it shows itself frequently associated with the efforts to contribute something new to the world. Thus it is to be identified with the will for creation—or invention, or discovery. Limiting ourselves to this analysis, education for design would ultimately mean nothing more than education for creativity.

Creativity, however, is also a notion which has been excessively abused in recent years. For many people education for creativity means education for self-expression. They maintain that creativity should be the result of a process of liberation from the inhibiting aspects of the personality. In other words any personality capable of expressing itself should be capable of creating. This is not true: no capacity for expression can replace the knowledge and experience required for the creation of a specific object. Of course the inhibited man is seldom a creative man, but this does not support the belief that people free of inhibitions are automatically creative people. Creation certainly is always an act of dissension, in some respects an act of revolt, but at the same time it is the result of an acquired instrumental skill.

Education for design has become a very complex task. We must train people capable of revolting against stereotyped ideas, but we must also equip them with the means to do this; otherwise the revolt is only declamatory. Moreover, in most cases the act of creation is not something beginning and ending in an individual. It is a social fact. To create is frequently to form the life of others, but in some cases it can contribute to deform and even to damage—or to destroy—the life of others. Thus education for design can be indifferent neither socially nor culturally, because design is not indifferent. Education for design is education for responsible creativity.

•
All the works illustrated in this paper were executed by students at the *Hochschule fuer Gestaltung*, Ulm, Germany, where the author is Director and Head of the Department of Industrial Design.



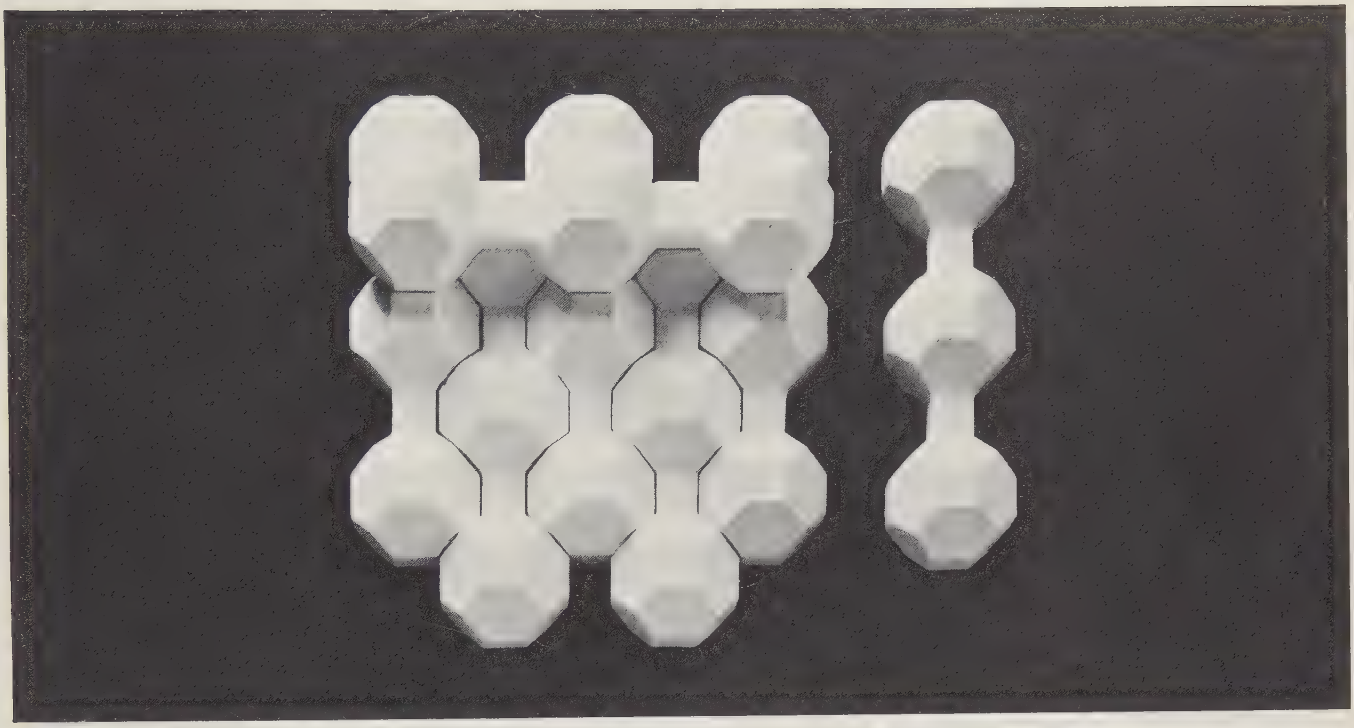
Now what are the underlying reasons for the sudden obstinate interest in the problem of training the industrial designer? Why has a subject matter until recently considered only sporadically, a subject matter we might call marginal, become the leitmotif of so many congresses and symposiums? Why do the professional industrial designers, hard and realistic as they are, or pretend to be, the majority of whom are so indifferent to the world of education, suddenly appear to be preoccupied with the pedagogical problem?

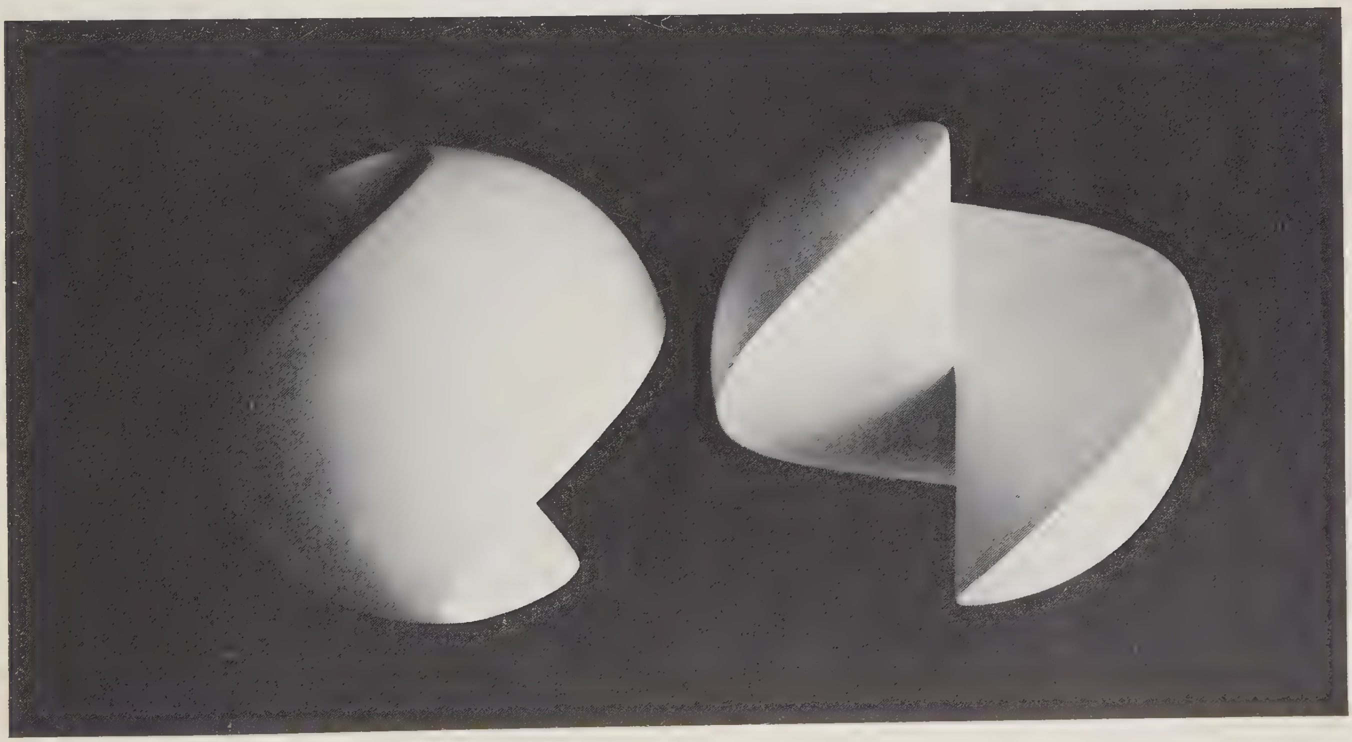
One possible reason, although certainly not the only one, is the fact that many industrial designers hope to find in education one of the most efficient means to stabilize and consolidate their profession. In other words, many share the opinion that, directly or indirectly, education might help to modify aspects of a situation within their field which they find alarming: precarious conditions, particularly psychological ones, under which they feel obliged to exercise their profession, lack of clarity with regard to their own social status, and a feeling of insecurity which accompanies this situation.

For quite a long time the industrial designer has been more interested in doing than in becoming conscious of his doing, more interested in extending his activities than in deepening them. From a certain point of view this extreme pragmatism has been justified. In the first phase of the development of any profession, action necessarily predominates over analysis. The new profession we are occupied with is no longer in its "first phase". Therefore, thorough self-examination, the clarification of one's own aims and methods is today no longer luxury for the industrial designer, but urgent necessity. Problems thought to be abstract until recently now begin to assume an absolutely concrete character. Vague and ambiguous notions no longer satisfy the industrial designer. On the contrary, little by little, he begins to perceive the discomfort of an insufficiently defined profession.

In reality, there is nothing less comfortable than being obliged to exercise an unlimited profession in a world of strictly limited professions: in other words, to exercise a profession whose beginning and end, whose own territory and that of the neighboring profession are unknown. Conflicts, dissensions, misunderstandings, discordant and troublesome situations characterize unequivocally the daily life of such a profession. Therefore we must not be surprised that the industrial designer so frequently runs the risk of being labelled a usurper, imposter or intruder. And better than anybody else, the industrial designer himself is particularly conscious of this constant risk and suffers from it. In all roles which he spontaneously undertakes or which he is obliged to undertake—artist, engineer, man of taste, sales promoter or manager—he can never rid himself of the unconfessed feeling of illegitimate appropriation. He is never convinced of the power which he has acquired or been conceded. In spite of the remarkable progress which has already been made, in spite of the overcrowded and superorganized offices of the most privileged representatives, the profession of the industrial designer still suffers from real or imaginary growing pains. It is still an immature profession because it still lacks that which characterizes maturity: the capacity to recognize its own limits.

The hope that education could help the industrial designer to consolidate and stabilize his profession socially is not unfounded. The historical development of modern professions abundantly





supports this view. Indeed, teaching a profession has always been the best way to ensure its stabilization and consolidation. Medicine, for instance, ceased to be a suspect activity and turned out to be a more or less serious science and dignified profession in the thirteenth century when it began to be taught at the University of Montpellier.

Teaching consists of passing on already organized knowledge; but in its beginnings teaching means the organization of knowledge, still informal and vacillating, not yet articulated. Without doubt teaching contributes more than any other activity to the clarification of the characteristic properties of a profession, i.e. the factors that make it possible to distinguish professions from each other.

Nothing, however, would be more erroneous than to oversimplify the relationship between a profession and professional training. The relationship is far more complex than would be supposed. Each field contributes to the formation of the other and both together effect their own integration into one superior unit. Consequently it is not a question of a passive, merely receptive relationship, but of an essentially active one, a true dialectic interaction and interdependence.

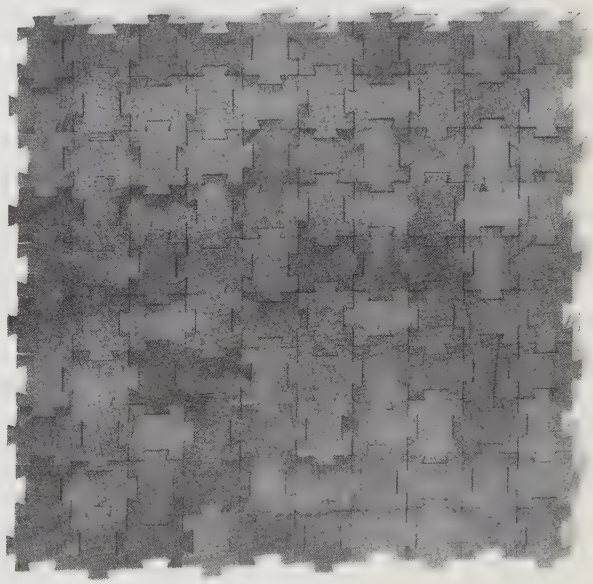
Industrial design is not exempted from this fact. Pedagogical practice may help to clarify the foundations of this profession; but in reality it turns out to be impossible to tackle this pedagogical practice successfully without any hypothesis about the type of profession to be taught. The situation is still more complicated if we realize that this hypothesis can only be elaborated on the basis of indications or stimulations from professional practice. The more we reflect upon the kind of difficulties which many industrial design schools have to face today, the more evident it becomes that many of these difficulties originate—directly or indirectly—from the vague formulation or the absolute lack of the aforementioned hypothesis. The climate of apathy, resignation and sterility which is to be found in many industrial design schools can be explained by the lack of clarity about what, how, and to what end one teaches.

It should be recognized, however, that this confusion in the restricted field of pedagogical activity is only a result of the same confusion in the broader field of professional activities. If the training of the industrial designer is disorderly and contradictory in general, it is due to the fact that the whole complex of industrial design, as a profession and as a philosophy of profession, continues to be confused and contradictory. In fact, as far as I know there has never before existed such a disconcerted phenomenon in such a successful and influential profession—a profession having such great receptivity to so many realities and at the same time such an indifference to its own reality.

As I have already noted, there have recently been signs indicating that the industrial designer is beginning to worry about this situation. His interest in the problems of the training of young men for this field constitutes one of the principal symptoms of this growing uneasiness. Nevertheless his preoccupations are always peripheral; they never succeed in either affecting or influencing his daily work. The vague suspicion—or even firm conviction—of the confused and contradictory character of his profession does not handicap him in continuing to exercise it with the same intensity and efficiency. On the other hand, for the educator the situation is very different. The realization of the confused and contradictory character of the aims of his activity may suddenly paralyze him, because the work of the educator is always finalistic, i.e. directed toward a specific end. His task may be as experimental, dynamic and open as you like, but his aims must—for a short or a long period—always be clearly defined. In this sense, the task of the educator has an alarming, anachronistic character. In today's fluctuating reality, in which all values—ethical, aesthetic, political, etc.—spontaneously tend to infinite diversity, it is difficult not to consider anachronistic a task which can be fulfilled only when at least one constant shall have been fixed: the constant of the human type to be realized. This is the indispensable requirement of any educational practice, including that of an industrial design school, whether or not we approve it or judge it to be in accord with the most progressive ideas. If this principle is not accepted, the training of the industrial designer—like any other training—will become an academic farce, and the educator will become a more or less cunning or indifferent functionary. Only a clear formulation of the type of profession that is to be propagated can turn an industrial design school into an organism sufficiently powerful and dynamic to justify its existence.

When we look at the present situation of the industrial designer, when we examine the many and different ways of performing this activity and also the many and different points of view that may be taken regarding this activity, we must confess that the first impression is desolate. The panorama is so heterogeneous that it seems impossible to obtain a coherent idea of industrial design as it is, or as it should be. But if we begin asking for the factors which determine this heterogeneity, the original panorama, while not losing its confused and contradictory character, takes on a clearer shape. The contrasts remain the same, but we can now ascertain coincidences, similarities, and common origins. There is not an unlimited number of ways and methods to practice and interpret industrial design. Consequently the ways and methods may be grouped in a few fundamental orientations.

I want now to sketch the characteristics of the three most important of these orientations. By so doing I hope to present with some coherence the present disoriented state of industrial design as a profession and as a philosophy of profession.



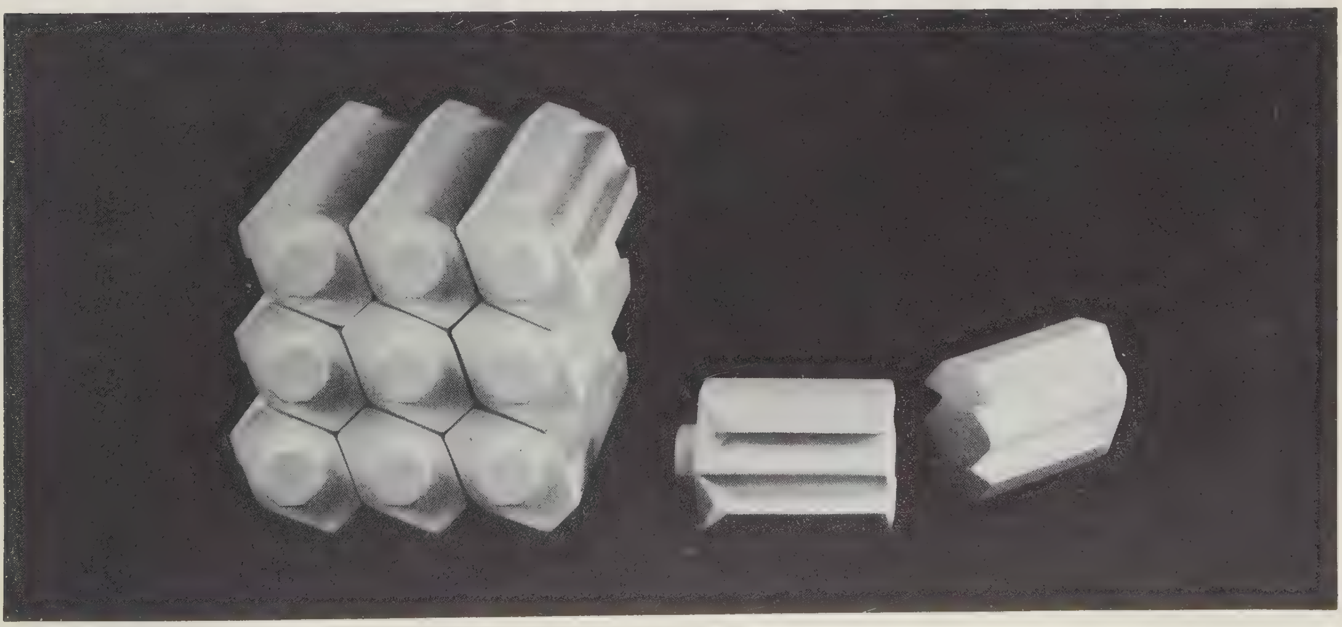
DESIGN AND SALES

In our competitive economy the most influential of these several orientations comes from those who consider industrial design principally or exclusively from the point of sales promotion. In the opinion of the representatives of this direction, industrial design would have a very specific aim in the world of merchandising: to stimulate the process permitting the conversion of latent demands into effective demands, the abstract needs into concrete needs, for example, to convert the necessity of washing clothes into the concrete need to acquire a specific washing machine—the washing machine of the firm with which the designer collaborates, and not the washing machine produced by a competitor. According to this view, the industrial designer can be considered as a real sales promoter—without euphemism, a salesman: and a salesman who not only knows how to make a salable product and sell it, but who also sells himself. But to sell successfully, to obtain a higher price for the object offered for sale, is not easy. Special talents are not enough. Special information is required, information concerning people's wishes to buy, concerning people's wishes to possess. This information the industrial designer can and should obtain with the aid of quantitative or qualitative market researches, i.e. with the help of scientific investigations permitting the relatively accurate establishment of how many persons prefer to buy a certain product and their motives for doing so.

This orientation, which began about 1930 and which conceives of industrial design mainly as a sales factor, has until recently not attracted appreciable adverse criticism. On the contrary, during the first fifteen years of its existence, this orientation had been praised as the most realistic and best adapted to the requirements of industrial production and the sales politics of big business. But immediately after the Second World War, especially in the United States, trends of opposition arose toward this orientation. They have taken shape mainly in certain progressive circles of economists and sociologists and particularly among the critics of American civilization. In these circles industrial design, at least in the way it is understood and practiced by the representatives of the orientation we are describing, has been judged in most inexorable and piercing terms as an activity without roots and specific purpose, an activity the essence of which consists only in converting the wishes and illusions of the masses into huge profits for the few. It has been implied that industrial design is not a profession to be taken seriously. In all known professions there is an ethic, a series of norms determining the behavior of its members. This ethic emphasizes the social responsibility of the profession: the necessity to place in all cases the interests of the community above the interests of the private individual himself, or above the interests of the group to which he is subordinated. For these critics, industrial design as profession lacks such an ethic.

Such attacks have not particularly troubled the industrial designers. They have considered them only an expression of the resentment of a few "highbrows" toward the people of success. Now however, though not confessing it, industrial designers are beginning to understand that their profession is more vulnerable than they had first imagined; they are beginning to understand that they must develop some kind of doctrine which could give this profession a character less in contradiction with the requirements of cultural and social progress.

Surprisingly, help is coming today from a group of intellectuals who—whether because of frivolity or conviction one does not know—have nothing to object to in the society in which they live. These are adjusted people, and adjusted, it would seem, because of good will. Their philosophy of industrial design is based on a theory of art (or anti-art) and on a theory of economics to which they adhere with touching gullibility. In their opinion the task of the industrial designer consists of realizing the "popular art" of our technical civilization, an art which interprets the genuine popular taste and which remains indifferent, if not hostile, to the values originating in the art of museums, to the values of the fine arts: thus, a strange mixture of Populism, Futurism and Dadaism, all of them outdated. In the "autosaurians" of Detroit this group believes it possible to rediscover the freshness and the creative imagination of popular art of all epochs. In the radiator of a Cadillac, they maintain, there are more original ideas than in all formal or informal pictures shown at the Biennale of Venice. This is the passion once again for that which Ernst Bloch called *verchromte Misere* (chromium-plated misery) but with the difference that they see no misery, but only wealth. They are really convinced that the industrial designer stimulates consumption, and that higher consumption corresponds to more individual and social plenitude, because higher consumption means more employment and more employment means more purchasing power for one and all. This is merely a new edition—neither revised nor enlarged—of one of the most persistent illusions of liberal economy: what is good for business is good for society. As recently formulated, "spending for the sake of spending" is equivalent to prosperity and patriotism. The economists—even the liberals—ceased long ago to believe in this marvelous "roundabout of happiness". "Consumerism" is not a universal panacea; it has its limits and dangers. One can continue to uphold the thesis which identifies the interests of business with the interests of society, but time renders this attitude more untenable from day to day.



DESIGN AND "GOOD DESIGN"

Another orientation I would like to deal with regards industrial design principally or exclusively from the point of view of its moral and aesthetic implications. Whereas in the field of production the influence of this orientation is very weak, in the field of the theoretical foundations of industrial design it is quite strong. The most influential ideas concerning industrial design, especially its cultural aspects, have been formulated to a great extent by the representatives of this orientation.

At first sight we are struck by the peculiar fact that the men most actively dedicated to the clarification of this profession are not, with few exceptions, the ones who put the profession most actively into practice; i.e. they are not those in collaboration with whom industry solves its daily problems. Without risking an oversimplification of the facts, I dare say that on one hand there are the designers with many ideas and few products, and that on the other hand there are designers with few ideas and many products. To try to explain this phenomenon only with the assistance of the traditional dichotomies of theoreticians and practitioners, idealists and realists, would be superficial and erroneous. Rather, the existence of designers with abundant ideas and few results can be connected closely with one of the following causes: (1) the ideas were absurd from any point of view; (2) although good in themselves, the ideas were incorrectly formulated; (3) although the ideas were good and correctly formulated, the historical conditions—economic, social, cultural, and technical—were scarcely suitable or absolutely unfavorable to the realization of the ideas. The impracticability of a great number of the ideas concerning industrial design can often be traced to the first and second reasons, but the third is by far predominant.

When we wish to understand such a situation in all its subtleties we must not forget that the attitude of the particular designers we are now discussing is essentially nonconformist. These men do not agree with the profession of industrial design as it is practiced today. At present they sympathize more with the idea of industrial design as an artistic movement rather than as a real profession. They do not admit, under any circumstances, that the primary function of industrial design is to stimulate sales. Nothing can irritate them more than the suspicion that they are salesmen to be had for a price. Although they are not always incorruptible in this sense, we must at least recognize that they wish to be so.

Another of the most distinctive characteristics of this group of designers, and certainly one which makes many of their ideas to a great extent impracticable, is their megalomania. Without exception they all have a very high opinion of themselves. Producers and consumers exist only for producing and acquiring objects which the designers decide shall be produced and shall be acquired. According to this point of view the industrial designers are the persons responsible for beauty and reason in a world ruled by ugliness and absurdity. They are the true apostles, the only champions of a truth which the majority of the people ignore. Certainly these industrial designers refuse commercialism and opportunism, but to consider them absolute nonconformists is an exaggeration. After all, their program is centered around the belief in the possibility of ameliorating the world by improving formally the objects of this world. In other words, they express unlimited confidence in the cathartic and also the revolutionary value of certain privileged forms. They advocate the importance of reaching absolute perfection and beauty of the object. By absolute perfection and beauty one must understand the optimal fitness between function and form of an object. Thus these nonconformists are often reproached—and not without reason—for their desperate cultural conformity, for what is essentially academicism. After the many and temerarious art experiments of our century it is difficult to continue to act as if nothing has happened, as if there exists something like a world of Platonic forms, a world of absolute perfection and beauty.

The attitude of the designers striving for the perfect form can be defined as essentially conservative. Its ultimate aim is nothing less than to consecrate as definite the forms they regard as perfect. Between these hunters of perfect forms and the champions of an hysterical obsolescence, between those desiring to eternalize the forms of the products and those wishing to modify them every six or twelve months, there are fewer differences than they themselves suppose. Both demonstrate the same purely formal, not the structural, way of thinking about the design of products. Both impede any fundamental and constructive reconsideration of the actual forms of the products.

DESIGN AND THE NONCOMPETITIVE SOCIETY

Finally, I do not want to leave unmentioned a third orientation, still in its early stage of development but nevertheless worthy of our acute attention. I refer to the particular direction in industrial design which is beginning to take shape in socialist countries where the economic and social structure is different from our own. The analysis of the present state and the eventual development of industrial design in these countries might serve to answer many questions, and to clarify our own thinking on the profession of the industrial designer. Is this profession to be considered an activity which is only justified within a competitive economy? Or is the function fulfilled by the industrial designer essentially the same in an economy in which competition tends to disappear or has already disappeared?

The Soviet designer Yuri Soloviev, in his contribution sent to the Aspen Congress (1961), declares that the profession of the industrial designer has to fulfill an important function in a noncompetitive society also. Furthermore, he suggests that this profession could have better possibilities in a noncompetitive than in a competitive society. Although I have not the slightest doubt that the industrial designer will keep his importance in a noncompetitive society, I do not share Mr. Soloviev's optimism that this kind of society necessarily offers *better* possibilities for the industrial designer. One must recognize, however, that although the industrial designer in a noncompetitive society is obliged to renounce certain creative and professional possibilities which are normally guaranteed to him in a competitive society, he is offered *other* new possibilities which the competitive society could not offer him.

Curiously enough, the industrial designer in the socialist countries is not fully conscious of the new possibilities his economic and social system—at least in theory—offers to his profession. If this were not so how can we explain that the frankly pathological manifestations of American and European industrial design are adopted by the Soviet designers as models worthy of imitation and perfection? One does not expect from the Soviet designers the imitation of our weaknesses, but rather the full exploitation of their own and specific possibilities. One expects them to tackle problems we are not allowed to tackle. For instance, technical products themselves require an urgent revision as far as their structural and functional properties are concerned, but in the framework of our competitive society initiative in this direction cannot be imagined, because the main activity of our society is to merchandise these products; it cannot accept any attempt to shake the artificially preserved stability of these products. The designers of a noncompetitive society are in a favorable position for attacking this new kind of task, but until now not very much has happened. One can only hope that this cannot be traced to the same reason which in the past caused Soviet architects and urbanists to commit such mistakes as maintaining naïve confidence in a tradition in which no one any longer believes.

A DEFINITION OF INDUSTRIAL DESIGN

By the analysis of these three orientations I hope to have shown sufficiently that industrial design, as a profession and as a philosophy of a profession, is a confused and contradictory reality, where absolute disorganization reigns. Now, under such circumstances, how can one define the aim of the training of the industrial designer? How can one find, in this labyrinth of different behaviors and opinions, a way toward an educational philosophy more or less unified and coherent?

Many have definitely renounced this effort or have decided to doubt the opportunity and even the usefulness of such work. I do not share this opinion. I personally believe that such a philosophy can be formulated and that such an aim can be defined, in spite of all difficulties. We must nevertheless proceed modestly, i.e. without excessive ambitions as regards the aim we are striving for. Above all we must not assume that the profession of the industrial designer can be specified with the same exactness as is possible in the case of the doctor, the chemist, the engineer, the agriculturist, or the veterinary surgeon.

I will risk giving a definition of the activity called industrial design. Further on I shall make use of this definition in pointing out the most distinctive features of the type of industrial designer the educator should try to train. As a very general definition I propose the following. *Industrial design is an activity whose ultimate aim is to determine the formal properties of the objects produced by industry. By "formal properties" is not meant the external features, but rather those structural and functional relations which convert an object into a coherent unity from the point of view of both the producer and the user.* The merely external features are often only the result of the intention to make an object superficially more attractive, or to dissimulate its constitutional deficiencies, and thus they represent an accidental reality, neither born nor developed together with the object. On the other hand, the formal properties of the object, as understood here, are always a consequence of a coordination and integration of all the factors—functional, cultural, technological, and economic—participating in one way or another in the formative process. The formal properties constitute a reality which corresponds to its innermost organization, a reality which is born and developed together with the object.

We must add that this definition of industrial design, without losing its general value, is indeed interpreted and practiced in different ways, which are attributable to one of the following factors: (1) the social and economic context, i.e. whether the profession is exercised in a competitive or noncompetitive society; (2) the degree of structural and functional complexity of the objects to be designed; (3) the degree of dependence of the particular object to be designed on the traditions of the craft and traditions of taste.

DESIGN EDUCATION AND SOCIAL RESPONSIBILITY

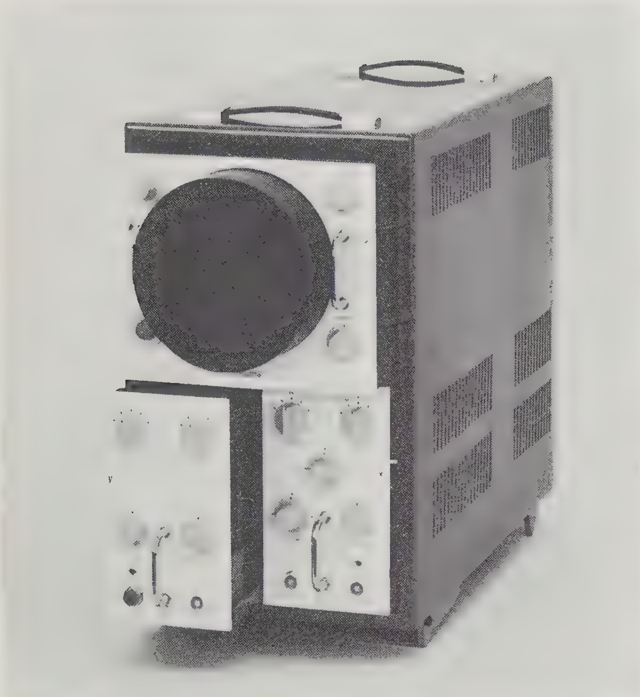
The outlines for an educational philosophy of industrial design can be deduced directly from the definition of the possible interpretative variances I have referred to. Sooner or later there will develop an integral and organic concept for the training of the industrial designer: a real training system, a constellation of different schools with different stages and different degrees of specialization. But this plan, which implies not only a very radical reform of the schools of art, arts-and-crafts, and architecture, but also of all schools of engineering, is too comprehensive to be explained here. Occasions will certainly not be lacking to explore this subject further. I limit myself here to indicating some of the most distinctive characteristics of the type of industrial designer which should become the guiding image of the whole system.

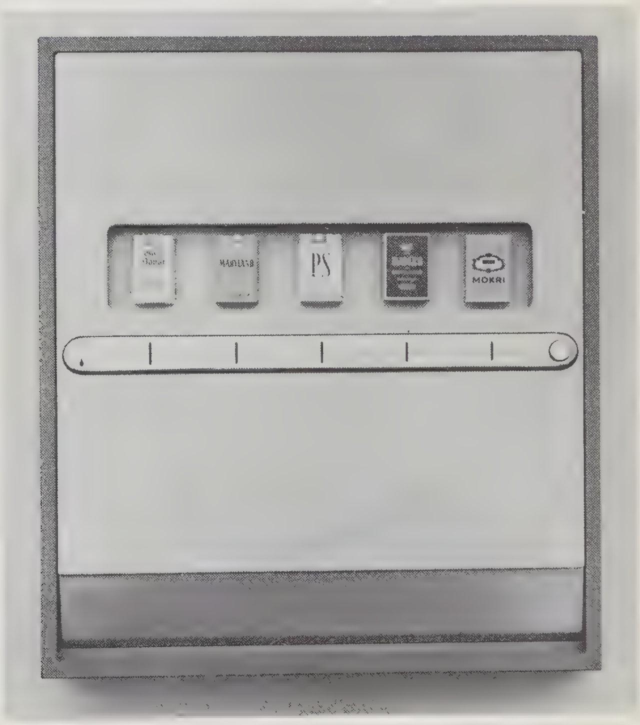
The industrial designer, as I conceive him, will be a man with high professional efficiency and great influence in a competitive society. Therefore I see him neither as spectator nor as judge, but as an active participant in the reality in which he acts and lives. He will be intensely dedicated to the task of equipping the world, but never to the extreme of ignoring or being indifferent to the conflicts, the calamities and the risks of the world he wants to equip.

The industrial designer will have to possess the knowledge and experience which are prerequisites for productive work in a society that is becoming every day more technicalized and where science plays from day to day a more decisive role. He will also have to overcome the objective and subjective difficulties arising out of the collaboration of representatives of the most different disciplines.

The industrial designer will know what is necessary concerning the cultural value of the objects, their meaning for individuals, and their meaning for individuals in relation to other individuals. His knowledge and his experience, nevertheless, should not impede but promote his freshness and creative spontaneity.

Finally, the industrial designer will be able to resist, even under the most unfavorable circumstances, the tendency to use his aptitudes for the design of products which stand in flagrant contradiction to the material and cultural interests of the consumers. This position of the industrial designer will not stem from the same reason or the same strategy as the very similar position of the preachers of purity we have discussed above. Rather the reason for this position will be a direct and self-evident confidence in certain human values which have to be preserved; its strategy will be founded not on arrogant demagogy, but on tough pursuit of the objective possibilities to preserve these values.

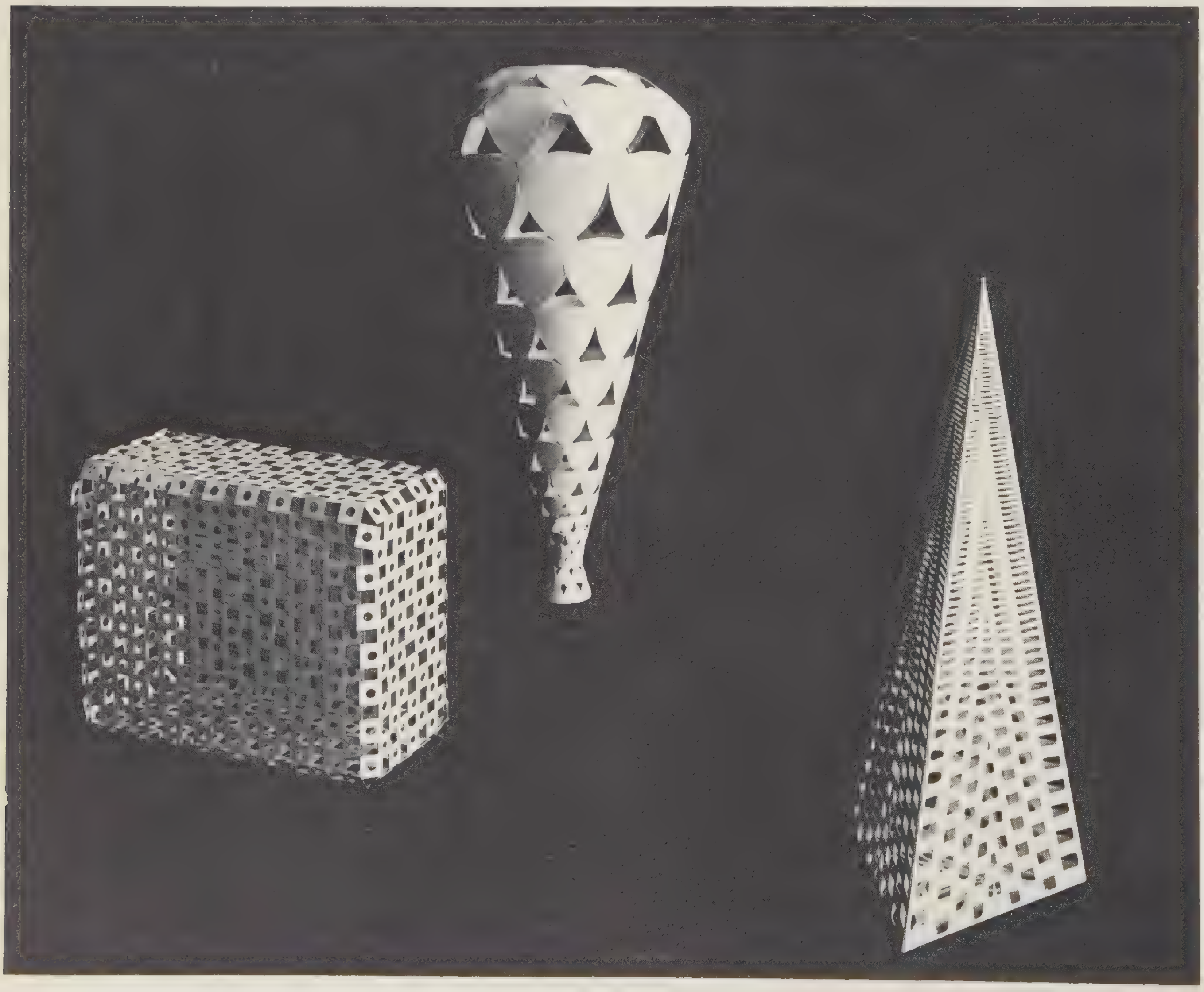


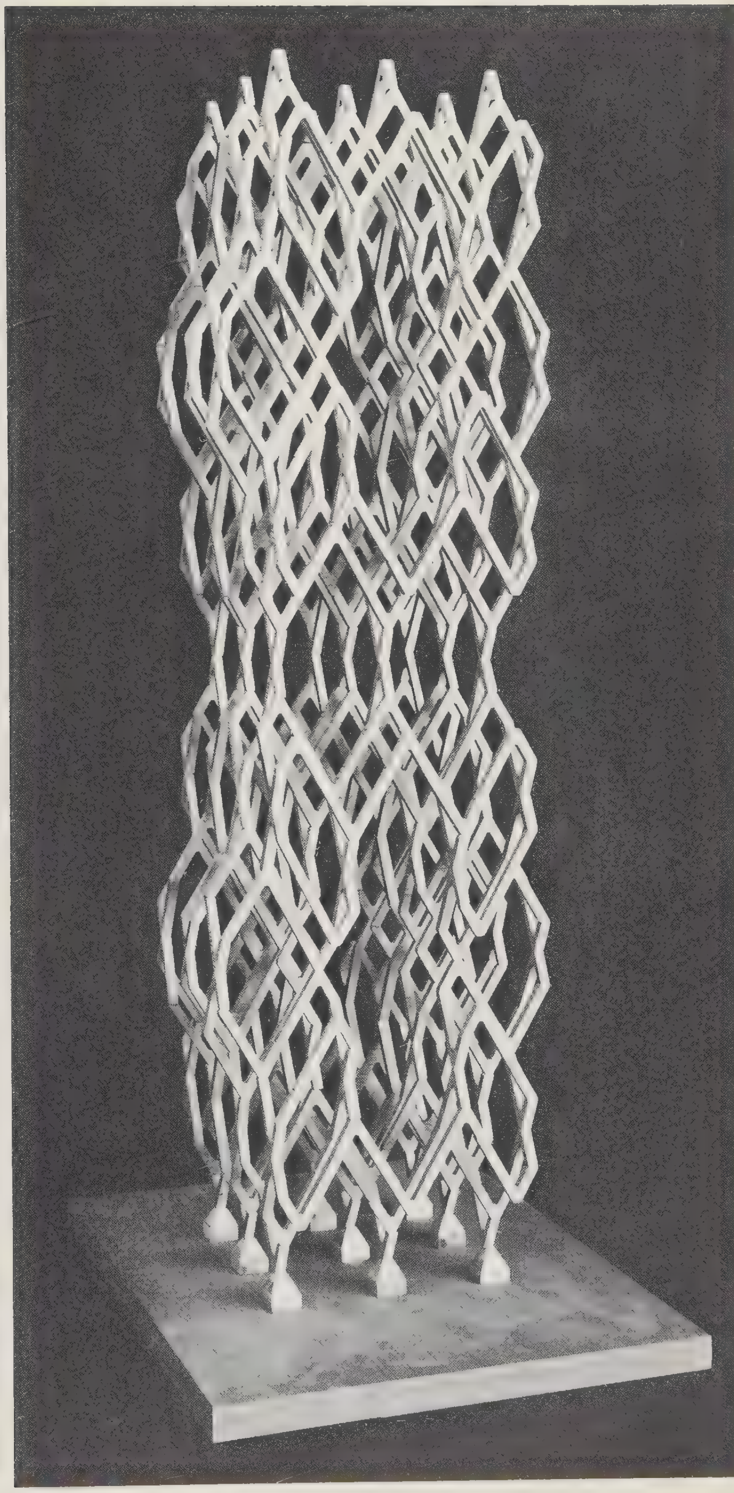

PS
MOKRI

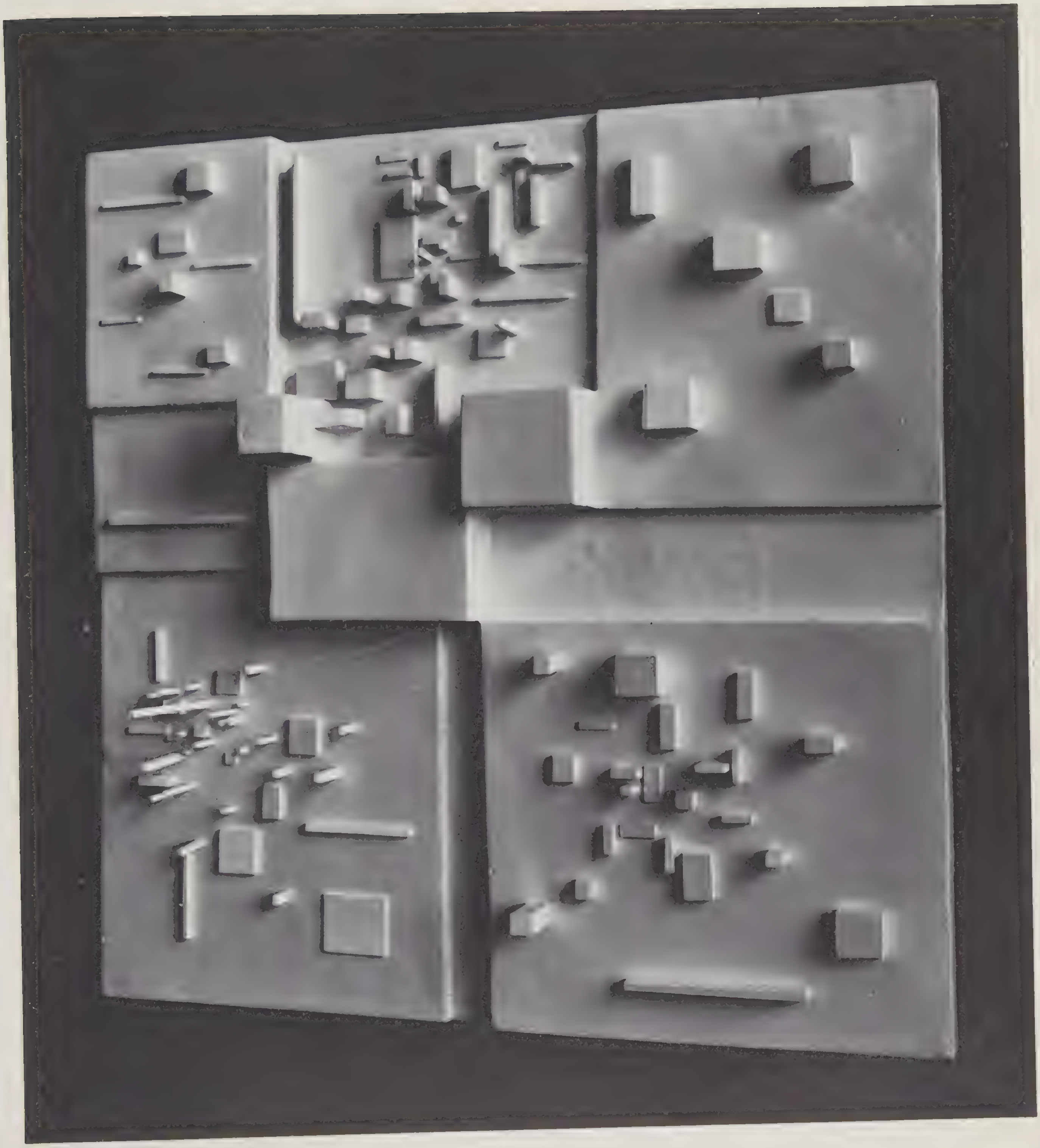
The illustrations on the following pages represent student work executed for visual design courses at Massachusetts Institute of Technology. These courses were first organized in 1946 by Gyorgy Kepes. Included here are: A: Studies from Form and Design course; B: Studies from Light and Color course.

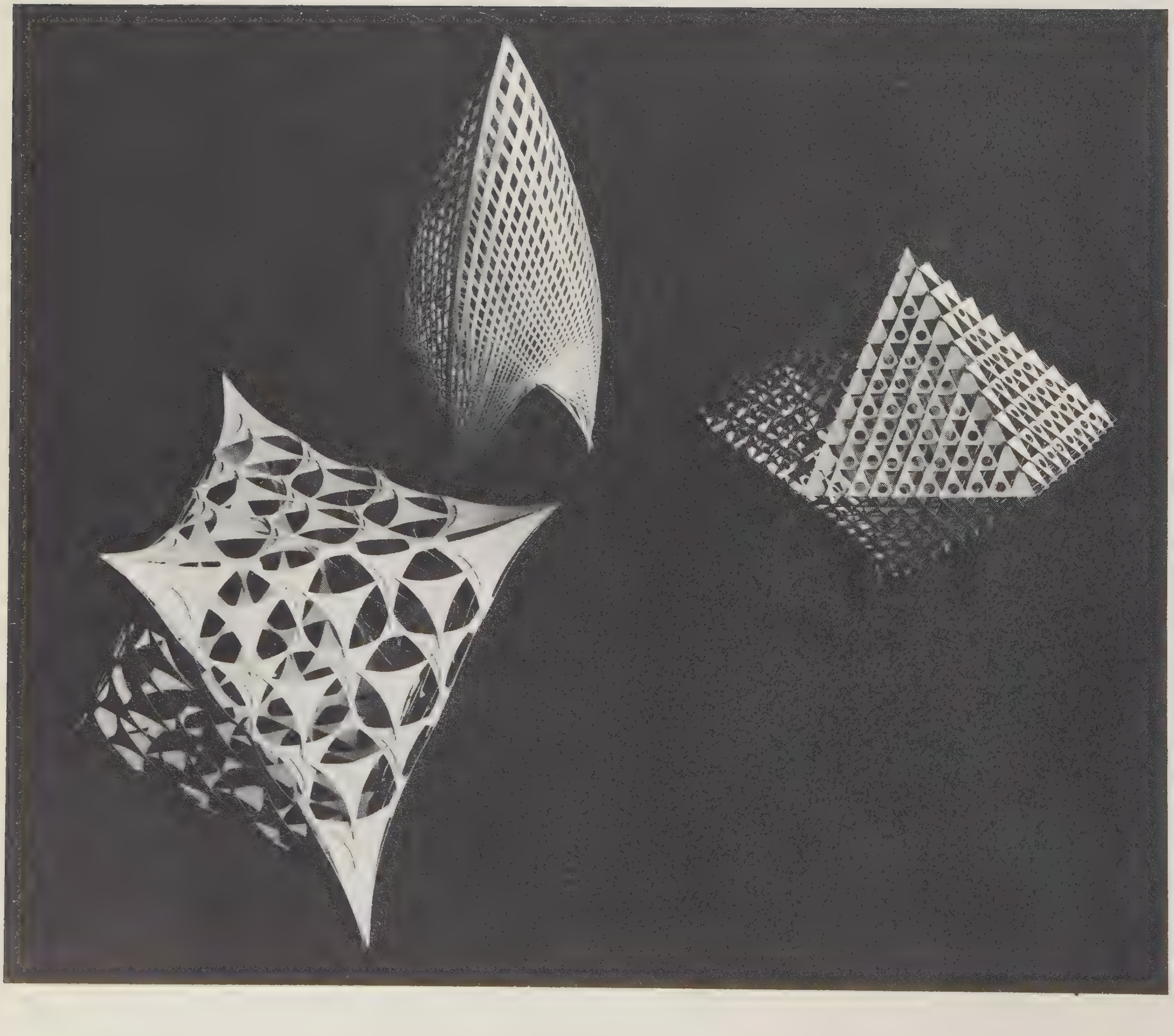
A:

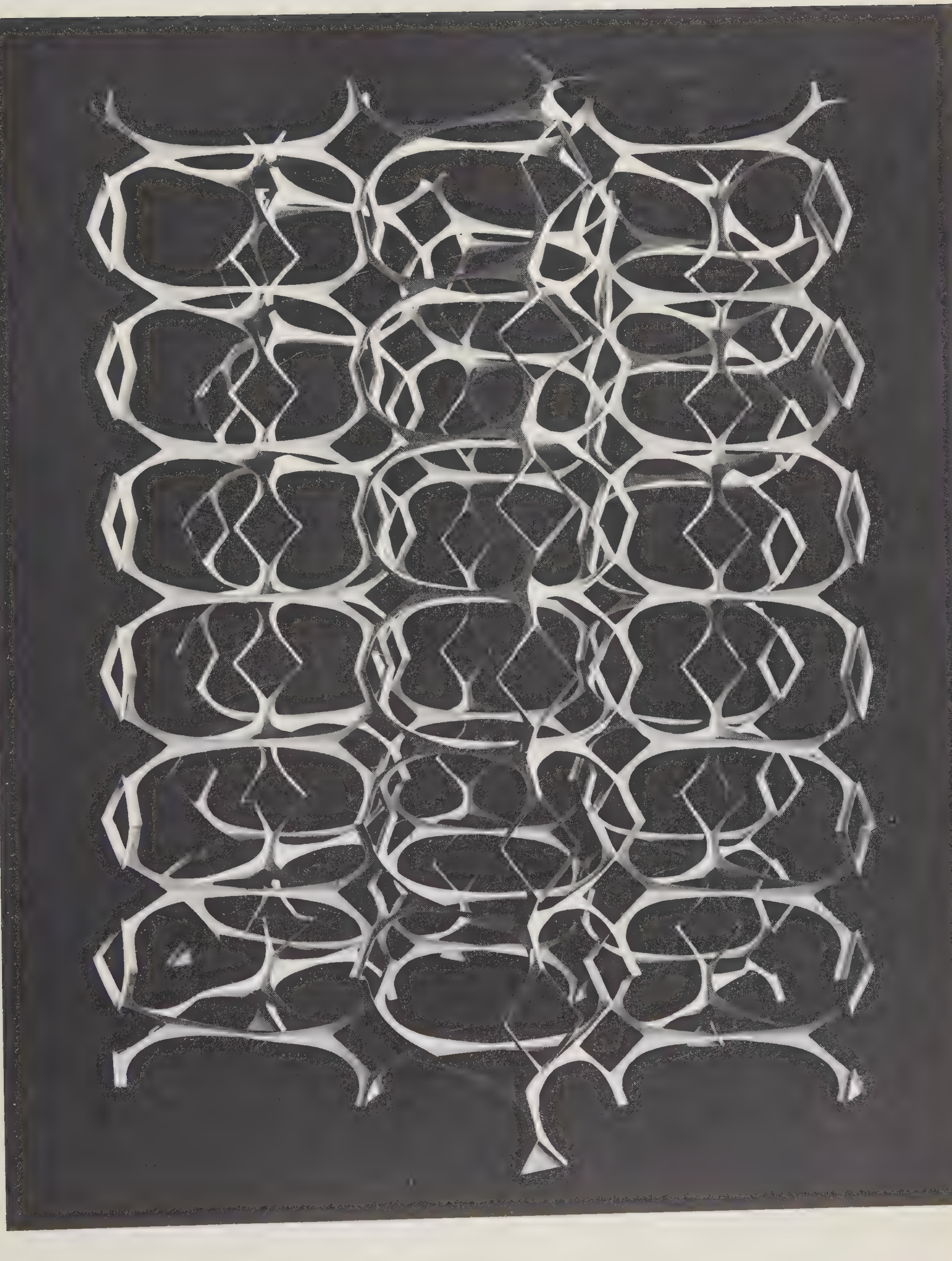
Studies from Form and Design Course, Massachusetts Institute of Technology.
Professor Richard Filipowski, in charge; photos by Nishan Bichajian.

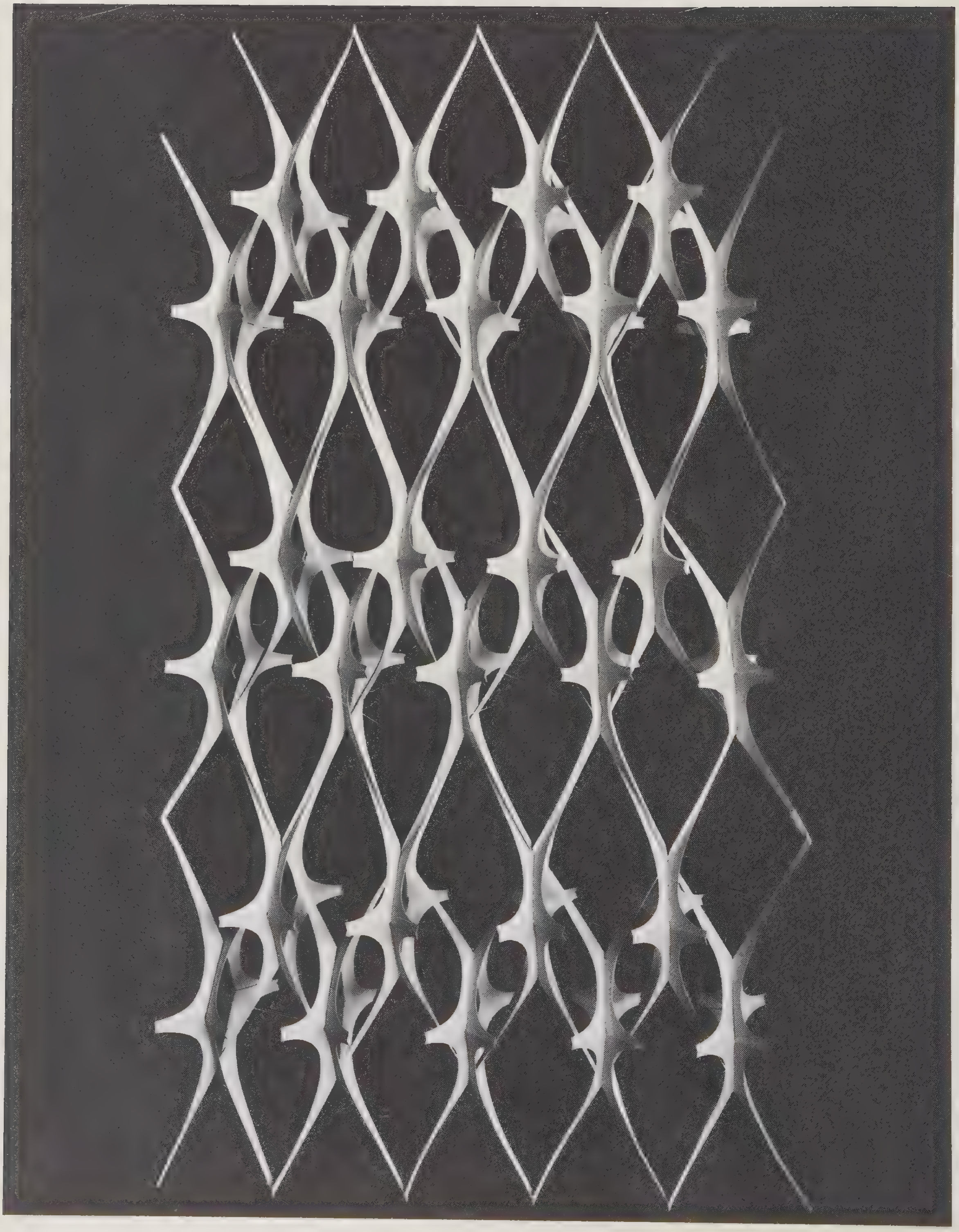


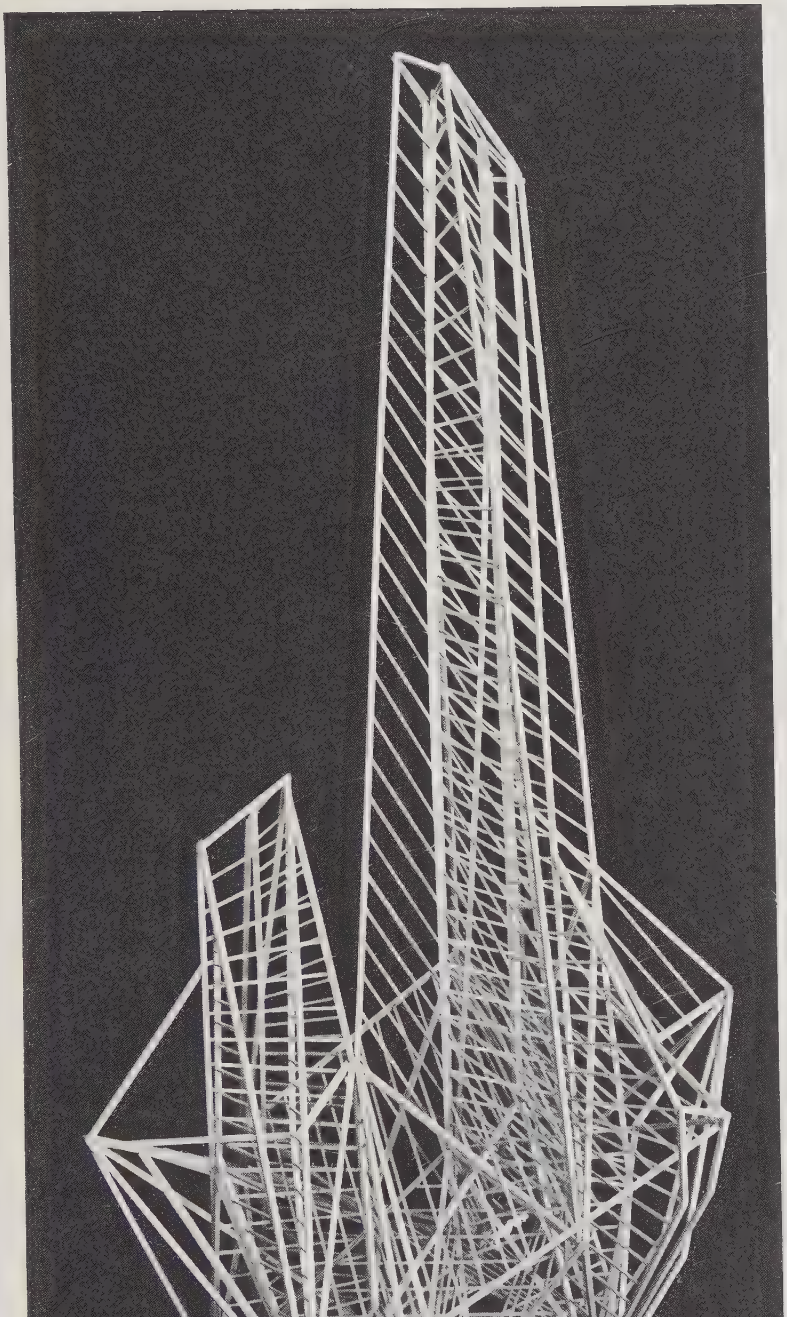




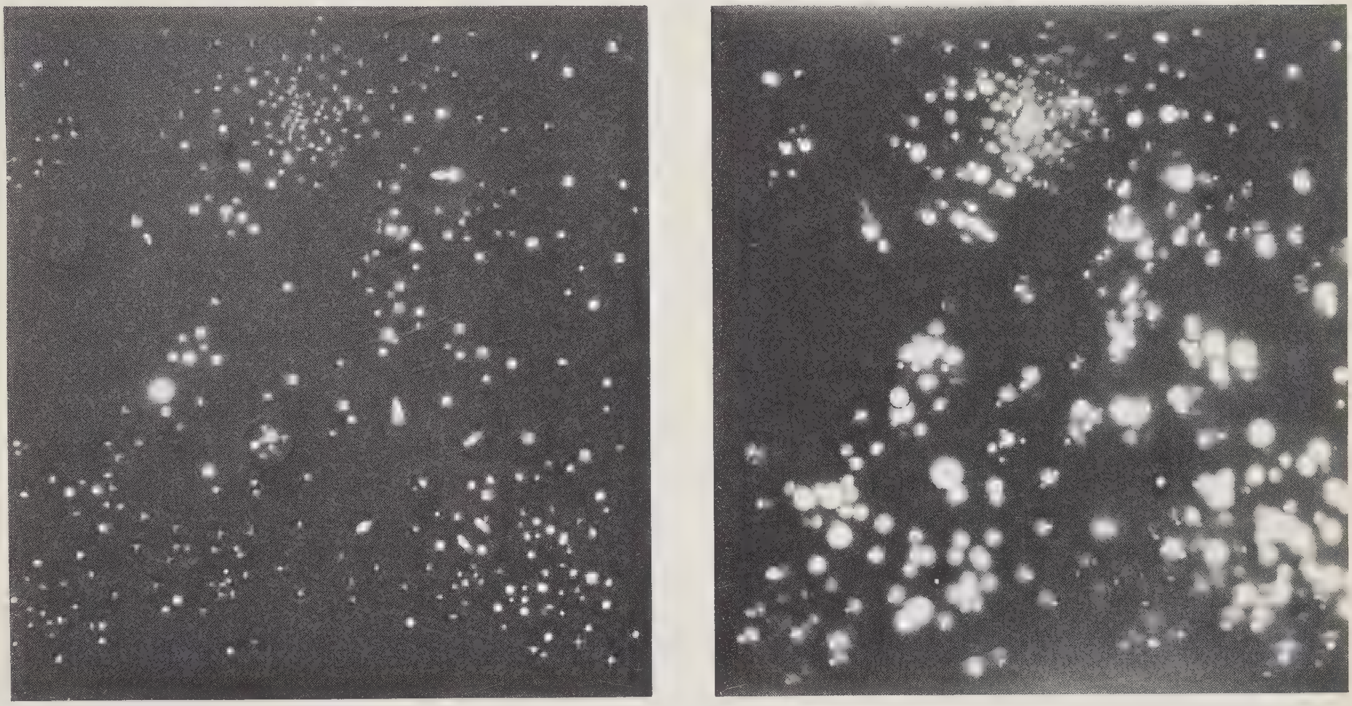




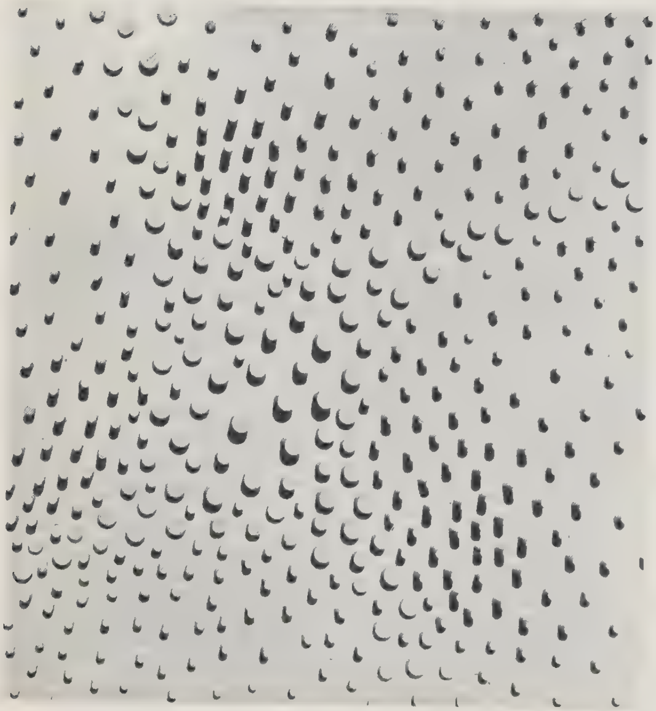


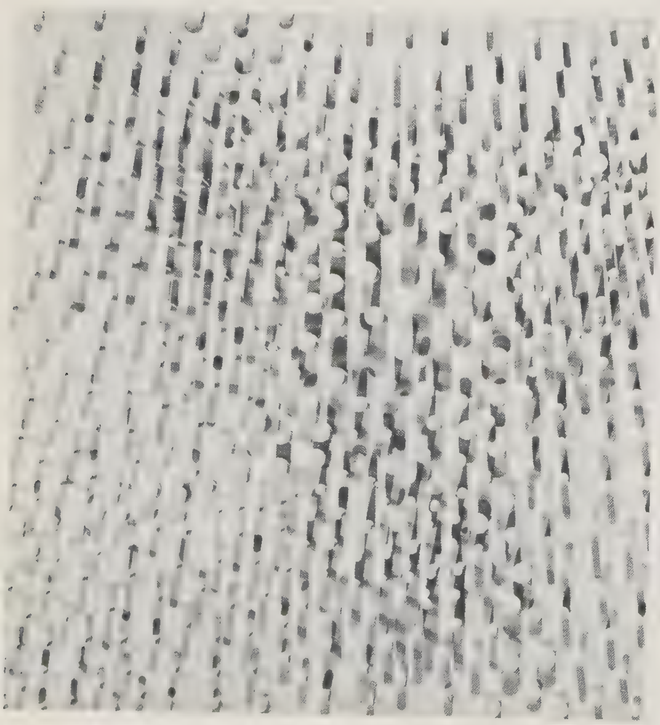


B:
Studies from Light and Color Course, Massachusetts Institute of Technology.
Professor Gyorgy Kepes, in charge; Nishan Bichajian, instructor.

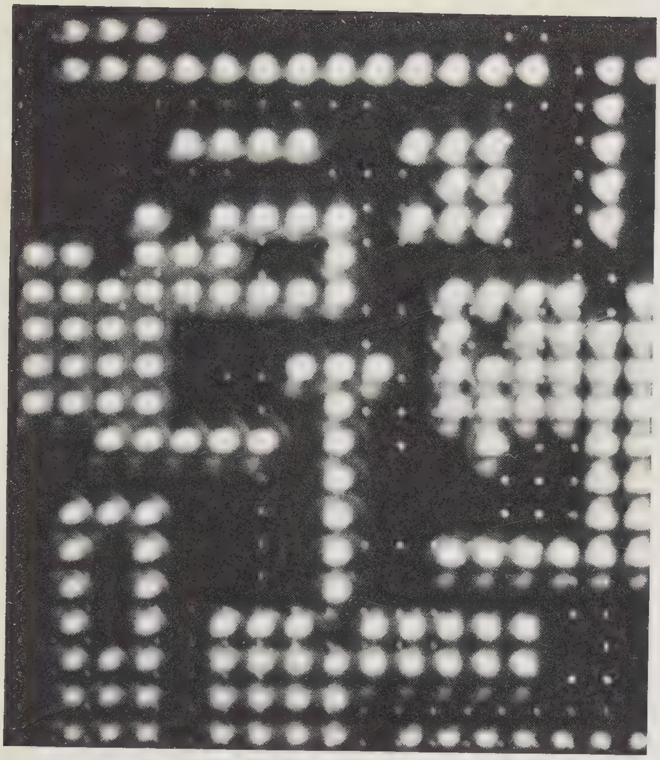


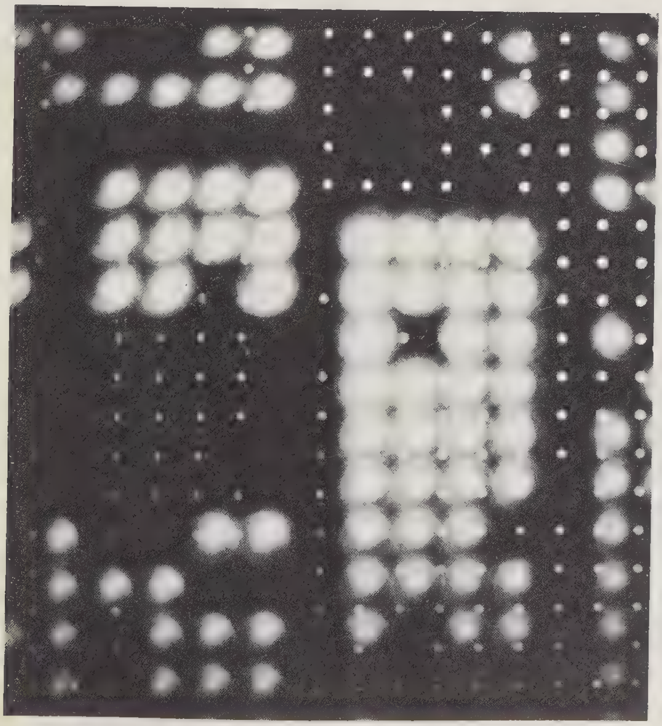
Transformation of Surface Texture through Illumination

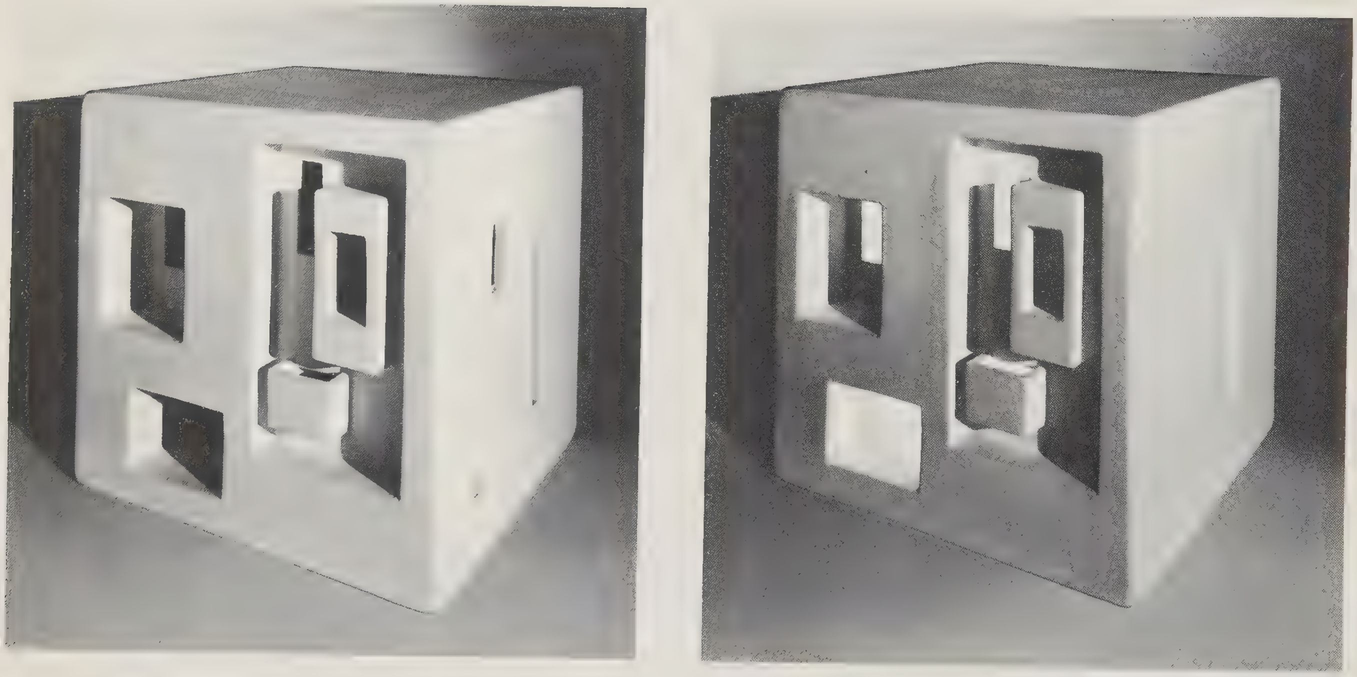




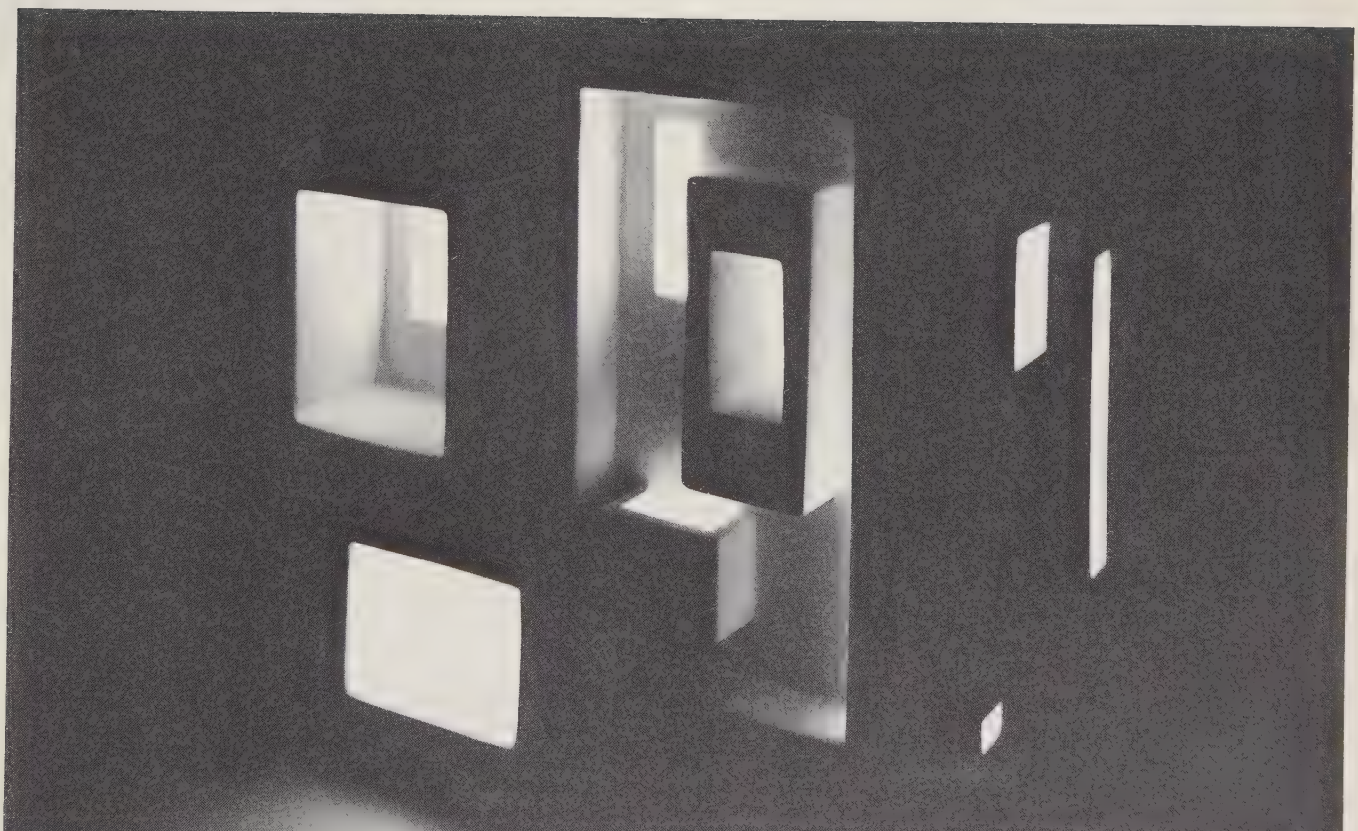
Light Textures

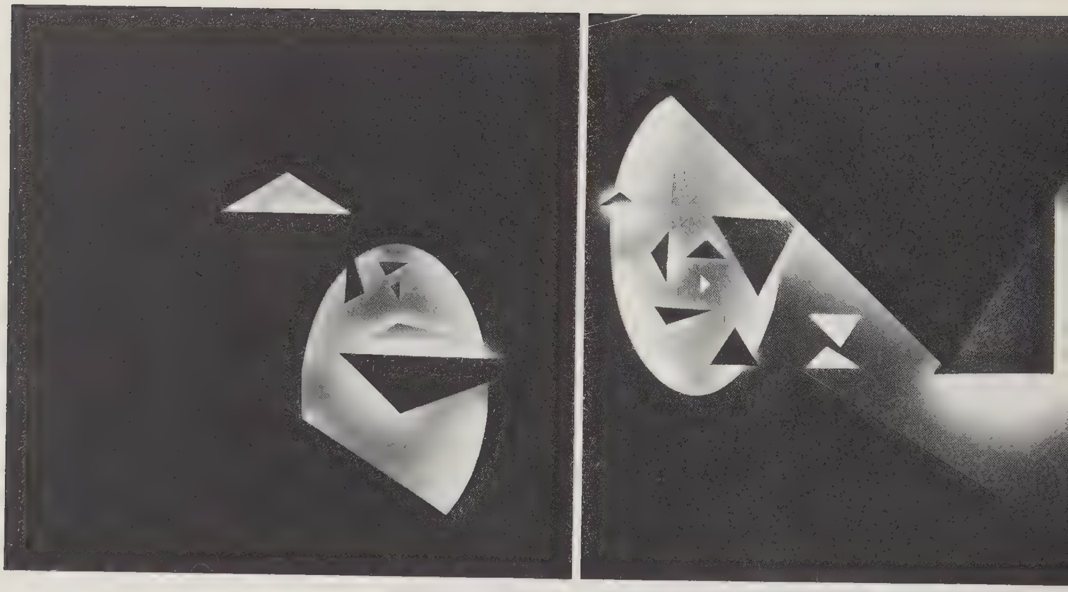




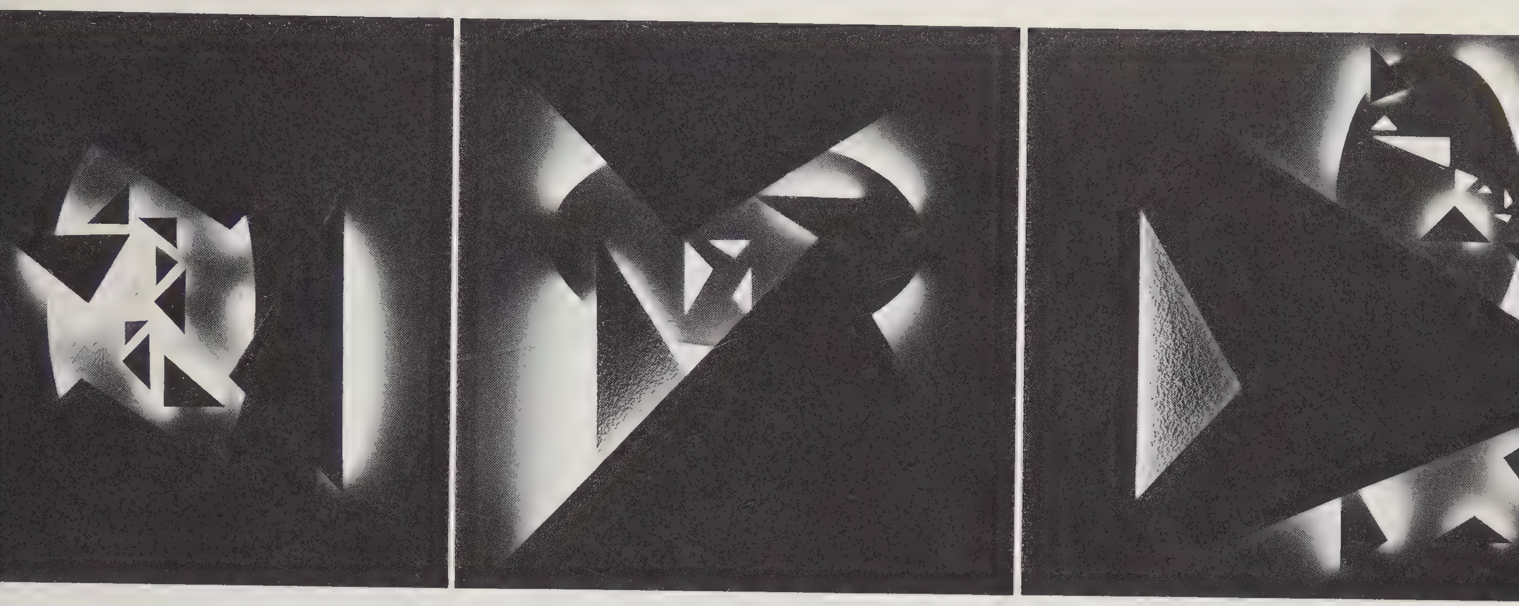


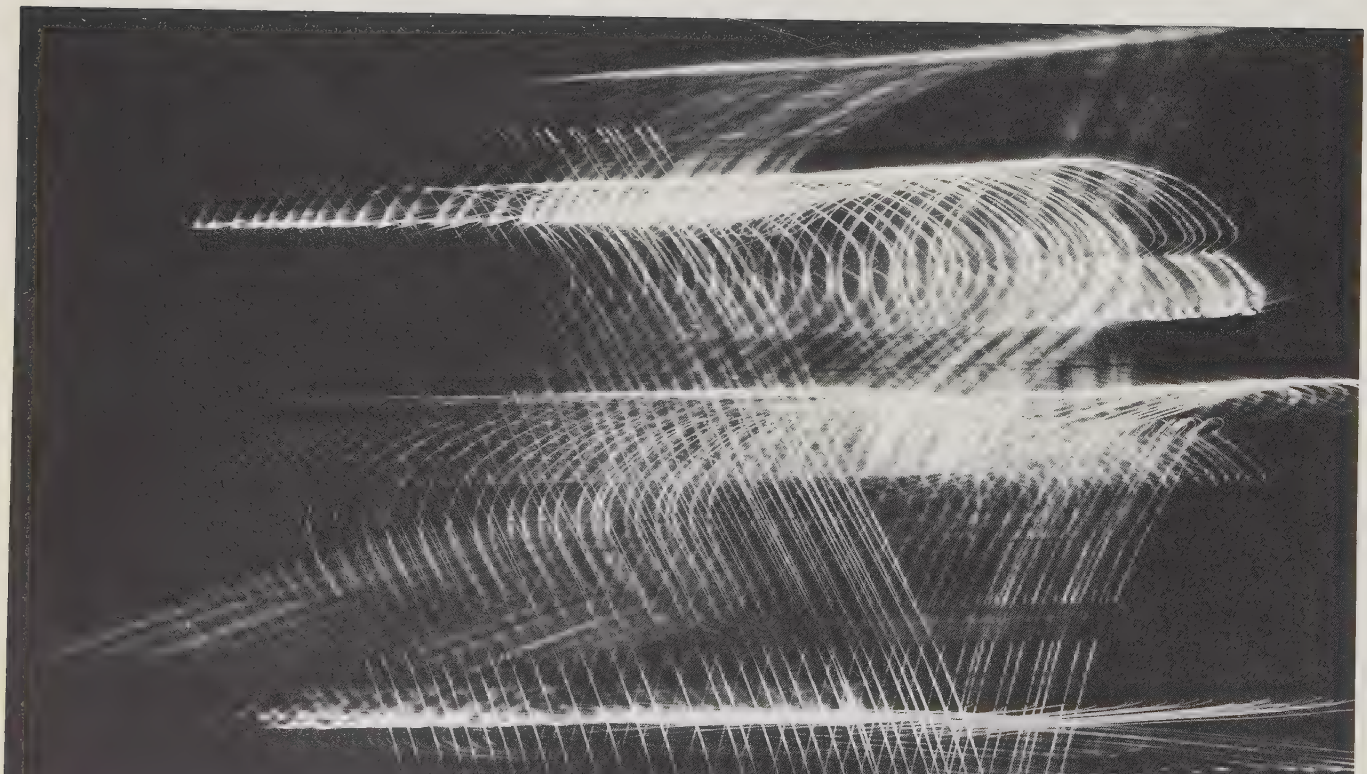
Transformation of Volume through Illumination





Study of Continuity by means of Illumination





The absence in art of a well-formulated and systematized body of literature makes the problem of teaching a perplexing one. The subject is further complicated by the elusive and personal nature of art. Granted that a student's ultimate success will depend largely on his natural talents, the problem still remains: how best to arouse his curiosity, hold his attention, and engage his creative faculties.

Through trial and error, I have found that the solution to this enigma rests, to a large extent, on two factors: the kind of problem chosen for study, and the way in which it is posed. I believe that if, in the statement of a problem, undue emphasis is placed on freedom and self-expression, the result is apt to be an indifferent student and a meaningless solution. Conversely, a problem with defined limits, implied or stated disciplines which are, in turn, conducive to the instinct of play, will most likely yield an interested student and, very often, a meaningful and novel solution.

Of the two powerful instincts which exist in all human beings and which can be used in teaching, says Gilbert Highet, one is the love of play. "The best Renaissance teachers, instead of beating their pupils, spurred them on by a number of appeals to the play-principle. They made games out of the chore of learning difficult subjects—Montaigne's father, for instance, started him in Greek by writing the letters and the easiest words on playing cards and inventing a game to play with them."[1]

Depending on the nature of the problem, some or all of the psychological and intellectual factors implicit in game-playing are equally implicit in successful problem-solving:

motivation	skill	excitement
competition	observation	enjoyment
challenge	analysis	discovery
stimulus	perception	reward
goal	judgment	fulfillment
promise	improvisation	
anticipation	coordination	
interest	timing	
curiosity	concentration	
	abstraction	
	discretion	
	discrimination	
	economy	
	patience	
	restraint	
	exploitation	

Without the basic rules or disciplines, however, there is no motivation, test of skill, or ultimate reward—in short, no game. The rules are the means to the end, the conditions the player must understand thoroughly, and work with, in order to participate. For the student, the limits of a well-stated problem operate in much the same way. "Limited means," says Braque, "beget new forms, invite creation, make the style. Progress in art does not lie in extending its limits, but in knowing them better."[2]

Unfortunately, in some of our schools little attempt is made to guide the student's thinking in a logical progression from basic design to applied design. We are all familiar with the so-called practical problems which attempt to duplicate the conditions of industry—the atmosphere of the advertising agency, for example. Such problems are frequently stated in the broadest terms with emphasis, if any, on style and technique in advertising, rather than on interpreting advertising in terms of visual design principles.

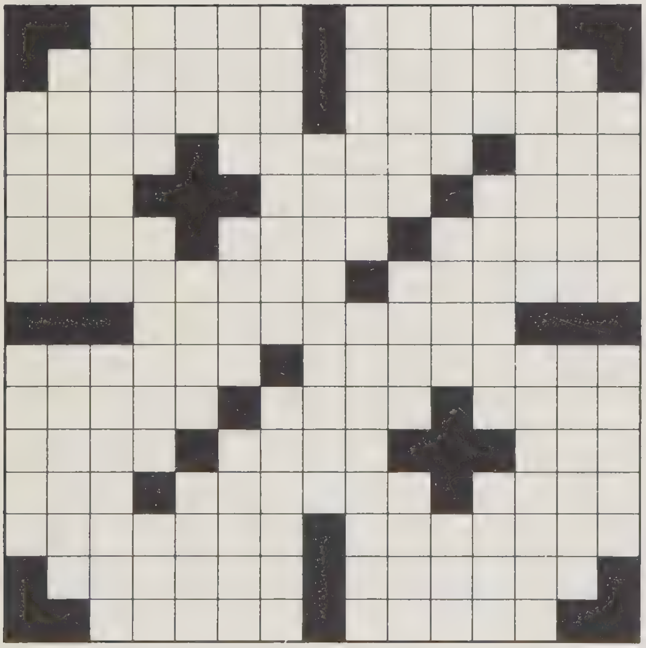
Without specific formal limitations, without the challenging possibilities of introducing the element of play, both teacher and student cannot help but be bored. The product may take the form of a superficial (but sometimes "professional looking") literal translation of the problem, or of a meaningless abstract pattern or shape, which, incidentally, may be justified with enthusiasm but often with specious reasoning.

Similarly, there are badly stated problems in basic design, stressing pure aesthetics, free expression, without any restraints or practical goals. Such a problem may be posed in this fashion: arrange a group of geometric shapes in any manner you see fit, using any number of colors, to make a pleasing pattern. The results of such vagaries are sometimes pretty, but mostly meaningless or monotonous. The student has the illusion of creating great art in an atmosphere of freedom, when in fact he is handicapped by the absence of certain disciplines which would evoke ideas, make playing with those ideas possible, work absorbing, and results interesting.

The basic design problem, properly stated, is an effective vehicle for teaching the possibilities of relationships: harmony, order, proportion, number, measure, rhythm, symmetry, contrast, color, texture, space. It is an equally effective means for exploring the use of unorthodox materials and for learning to work within specific limitations.

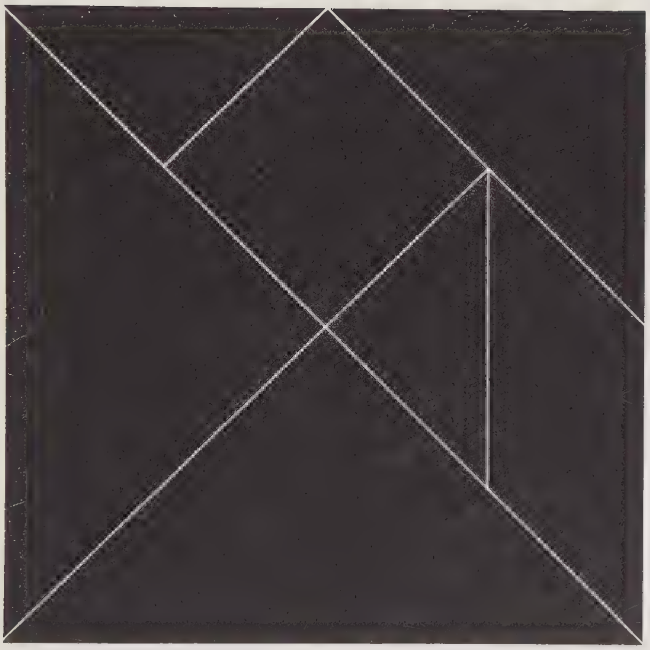
To insure that theoretical study does not end in a vacuum, practical applications of the basic principles gleaned from this exercise should be undertaken at the proper time (they may involve typography, photography, page layout, displays, symbols, etc.). The student learns to conceptualize, to associate, to make analogies; to see a sphere, for example, transformed into an orange, or a button into a letter, or a group of letters into a broad picture. "The pupils," says Alfred North Whitehead, "have got to be made to feel they are studying something, and are not merely executing intellectual minuets."[3)]

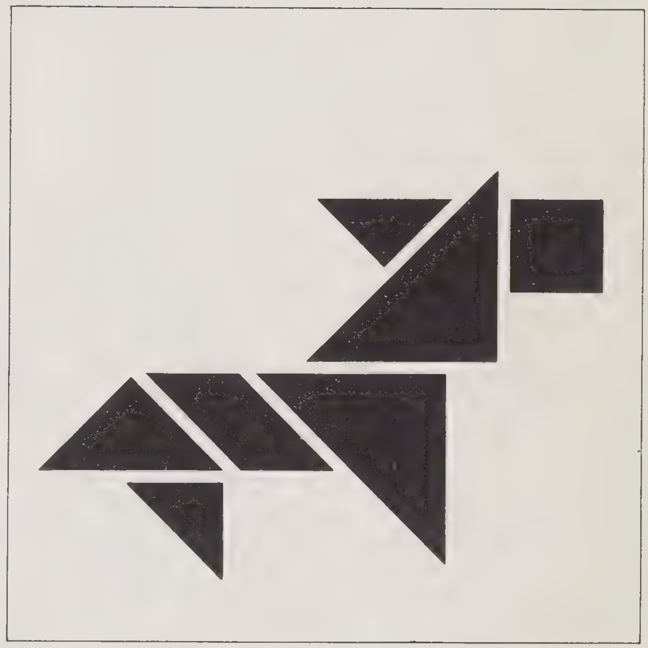
If possible, teaching should alternate between theoretical and practical problems—and between those with tightly stated "rules" imposed by the teacher and those with rules implied by the problem itself. But this can happen only after the student has been taught basic disciplines and their application. He then is able to invent his own system for "playing the game". "A mind so disciplined should be both more abstract and more concrete. It has been trained in the comprehension of abstract thought and in the analysis of facts."[4)]



There are many ways in which the play-principle serves as a base for serious problem-solving, some of which are discussed here. These examples indicate, I believe, the nature of certain disciplines and may suggest the kind of problems which will be useful to the student as well as to the teacher of design.

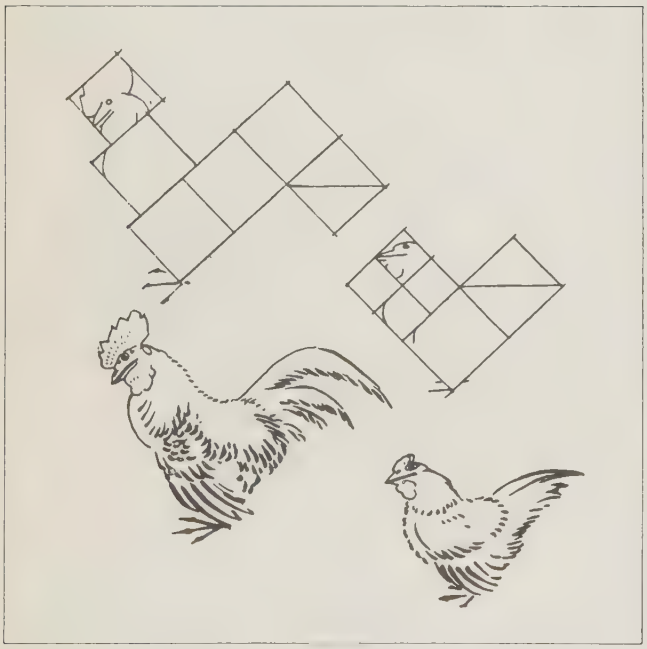
The crossword puzzle is a variation on the acrostic, a word game that has been around since Roman times. There have been many reasons given for the popularity of the game. One is that it fulfills the human urge to solve the unknown, another that it is orderly, a third that it represents, according to the puzzle editor of the *New York Times,* "a mental stimulation . . . and exercise in spelling and vocabulary-building".[5] But the play in such a game is limited to finding the exact word to fit a specific number of squares in a vertical and horizontal pattern. It allows for little imagination and no invention or aesthetic judgment, qualities to be found in abundance, for example, in the simple children's game, the Tangram.





The Tangram is an ingenious little Chinese toy in which a square is divided into this configuration. It consists of seven pieces, called "tans": five triangles, one square, and one rhombus. The rules are quite simple: rearrange to make any kind of figure or pattern.

Here above is one possibility. Many design problems can be posed with this game in mind, the main principle to be learned being that of economy of means—making the most of the least. Further, the game helps to sharpen the powers of observation through the discovery of resemblances between geometric and natural forms. It helps the student to abstract: to see a triangle, for example, as a face, a tree, an eye, a nose, depending on the context in which the pieces are arranged. Such observation is essential in the study of visual symbols.

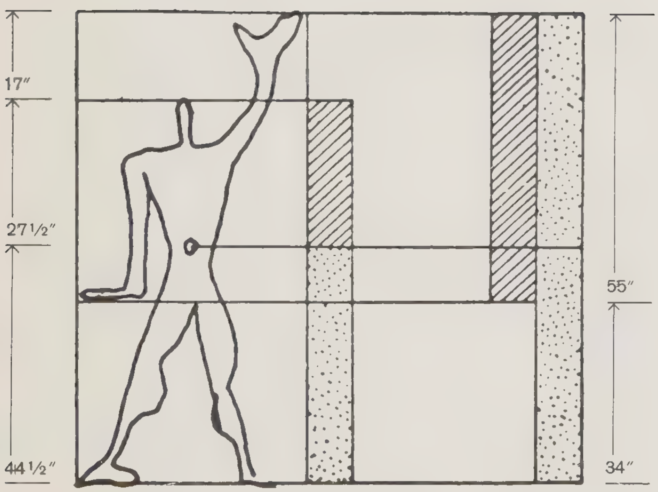


This drawing is reproduced from the first volume of Hokusai's *Rapid Lessons in Abbreviated Drawing* (Riakougwa Hayashinan, 1812). In the book Hokusai shows how he uses geometric shapes as a guide in drawing certain birds. This exercise may be compared to the Tangram in that both use geometric means. The Tangram, however, uses geometry as an end in itself—to indicate or symbolize natural forms—whereas Hokusai uses it as a clue or guide to illustrate them. In the artist's own words, his system "concerns the manner of making designs with the aid of a ruler or compass, and those who work in this manner will understand the proportion of things".

This character for the word "tan" (sunrise) is designed within an imaginary grid. Geometry functions here in a manner similar to the previous illustration, namely as a guide to filling the space correctly, but not to produce a geometric pattern.

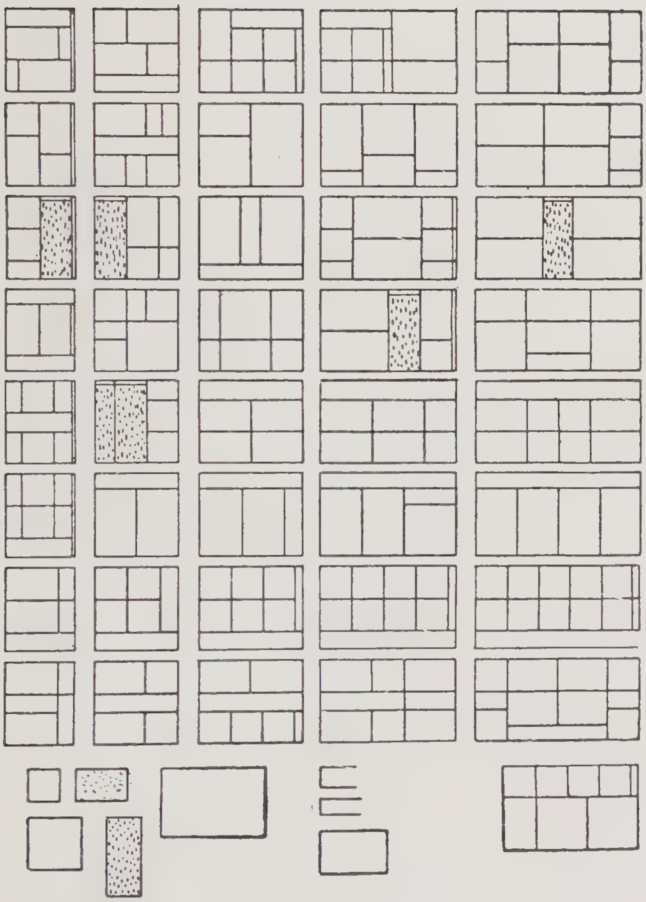
The Chinese character is always written in an imaginary square. The ninefold square, invented by an anonymous writer of the T'ang dynasty, has been employed as the most useful, because it prevents rigid symmetry and helps to achieve balanced asymmetry.[6] At the same time it makes the writer aware of negative and positive spaces. Each part of the character touches one of the nine squares, thus achieving harmony between the two elements and the whole.

Within this rather simple discipline the calligrapher is able to play with space, filling it as he feels would be most appropriate. The composition of Chinese characters, says Chiang Yee, "is not governed by inviolable laws . . . however, there are general principles which cannot be ignored with impunity".[7]



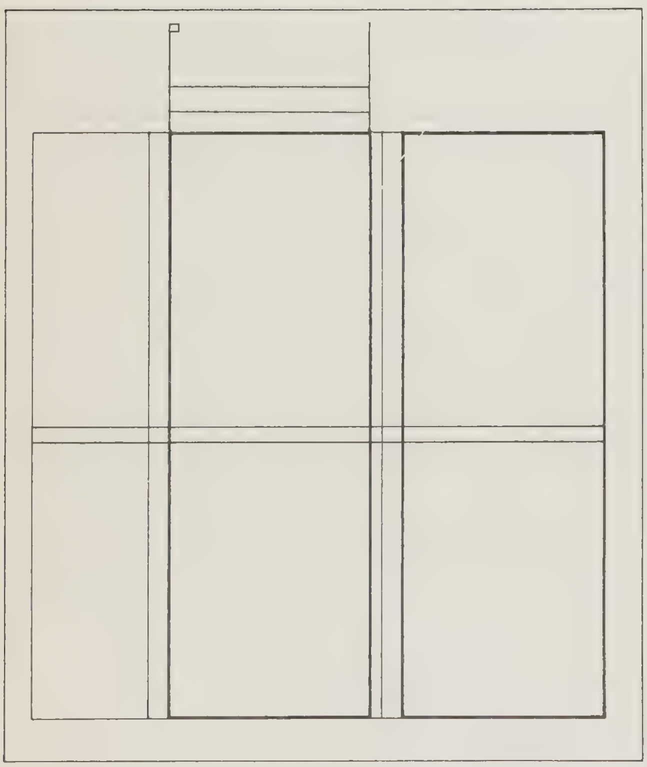
The Modulor is a system based on a mathematical key. Taking account of the human scale, it is a method of achieving harmony and order in a given work.

In his book, *The Modulor,* Le Corbusier describes his invention as "a measuring tool (the proportions) based on the human body (*6-foot man*) and on mathematics (*the golden section*). A man-with-arm-upraised provides, at the determining points of his occupation of space—foot, solar plexus, head, tips of fingers of the upraised arm—three intervals which give rise to a series of golden sections, called the Fibonacci series."[8] (*1, 1, 2, 3, 5, 8, 13, etc.*) (Italics are mine.)



The Modulor is a discipline which offers endless variations and opportunities for play. Le Corbusier's awareness of these potentialities is evident from the numerous references to the game and play in his book, such as: "All this work on proportioning and measures is the outcome of a passion, disinterested and detached, an exercise, a *game*."[9] Further, he goes on to say, "for if you want to *play modulor* ..."[10]

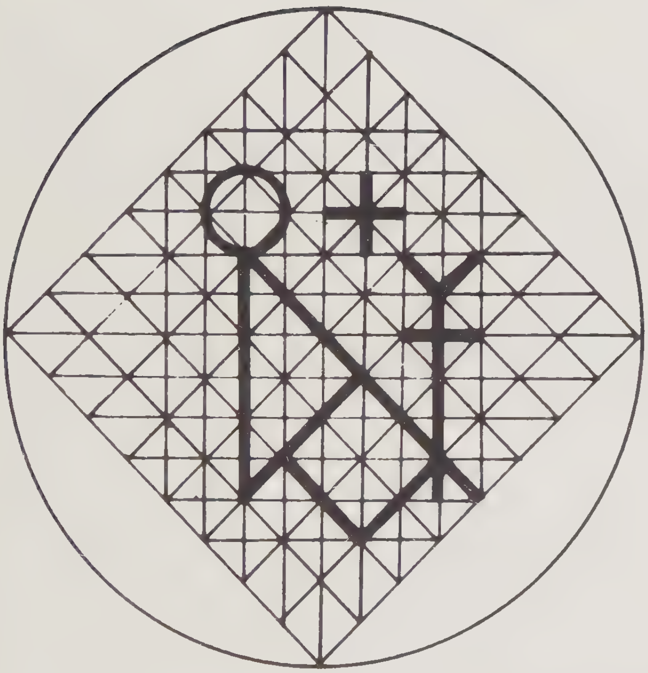
In comparison to most so-called systems of proportion, the Modulor is perhaps the least confining. The variations, as will be seen from this illustration, are practically inexhaustible (and this example utilizes only a very limited number of possibilities). If, however, the system presents any difficulties which happen to go counter to one's intuitive judgment, Le Corbusier himself provides the answer: "I still reserve the right at any time to doubt the solutions furnished by the Modulor, keeping intact my freedom which must depend solely on my feelings rather than on my reason."[11]



Like the architect's plan, the grid system employed by the graphic designer provides for an orderly and harmonious distribution of miscellaneous graphic material. It is a system of proportions based on a module, the standard of which is derived from the material itself. It is a discipline imposed by the designer.

Unlike the Modulor, it is not a fixed system based on a specific concept of proportion, but one which must be custom-made for each problem. Creating the grid calls for the ability to classify and organize miscellaneous material, with sufficient foresight to allow for flexibility in handling content which may, for one reason or another, be altered. The grid must define the areas of operation and provide for different techniques, pictures, text, space between text and pictures, columns of text, page numbers, picture captions, headings and other miscellaneous items.

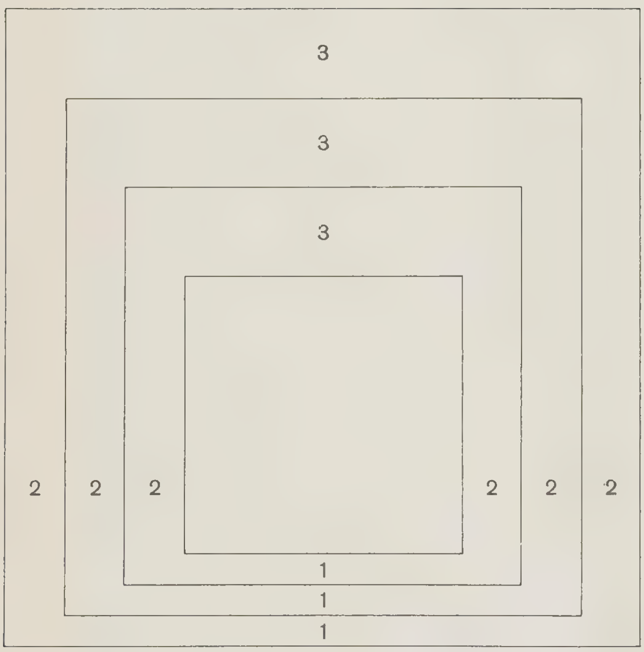
Here is a simple grid system for a booklet. Devising such a grid involves two creative acts: developing the pattern that is suitable for the given material and arranging this material within the pattern. In a sense, the creative ability required for the former is no less than that for the latter, because the making of the grid necessitates analyzing simultaneously all the elements involved. But once it is evolved, the designer is free to play to his heart's content: with pictures, type, paper, ink, color, and with texture, scale, size and contrast.



The grid, then, is the discipline which frees him from the time-consuming burden of making certain decisions (dimensions, proportions) without which fruitful and creative work is extremely difficult. He can move directly to those aspects of the problem in which individual expression, novel ideas, and freedom of choice are essential.

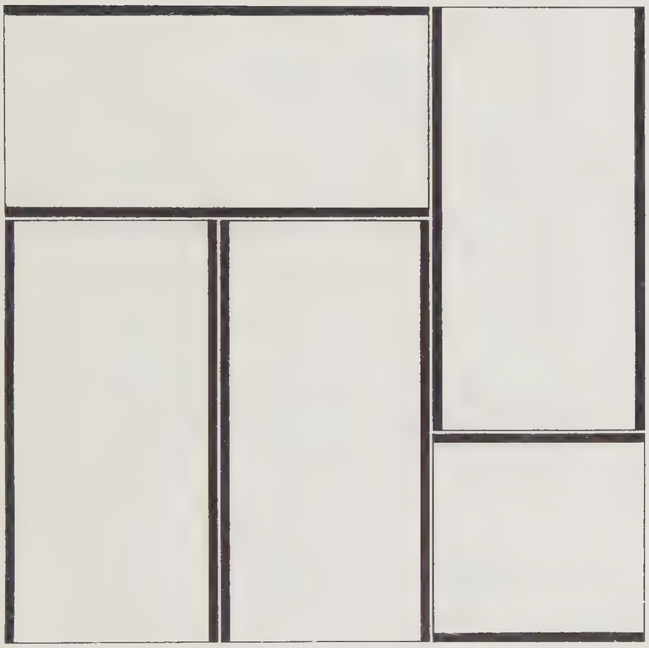
The grid system has as many detractors as it has adherents. It has been condemned as stifling, rigid and cold. But this is to confuse the product with the process. The grid does not automatically insure an exciting product. The designer must still exercise all the experience at his command, discretion, timing, and a sense of drama and sequence. In brief, the intelligent designer will recognize that the grid can help him achieve harmony and order, but also that it may, when and if necessary, be abandoned.

In addition to those already discussed, variations of the geometric plan are to be found, among other places, in Japanese architecture, modern painting, and in Byzantine masons' marks, such as the seal at left. This seal "employs a mathematical key as its design basis. The thick lines represent the mark, the thin lines represent the ground lattice which allows an infinite number of combinations."[12] The geometric scheme is the discipline in which the designer works. Designs stemming from such a scheme are limited only by his imagination.



Much of the painting of Josef Albers is based on this geometric pattern. The pattern is not used, however, in the same manner as the masons' lattice. Here it is the painting itself. It represents a strict, immutable arrangement (theme) in which the artist, by juxtaposing colors (variations) plays the fascinating game of deceiving the eye. The squares as we see them here appear to recede into the picture plane. However, by skillful manipulation of colors, the painting flattens out and is thus seen as a two-dimensional picture.

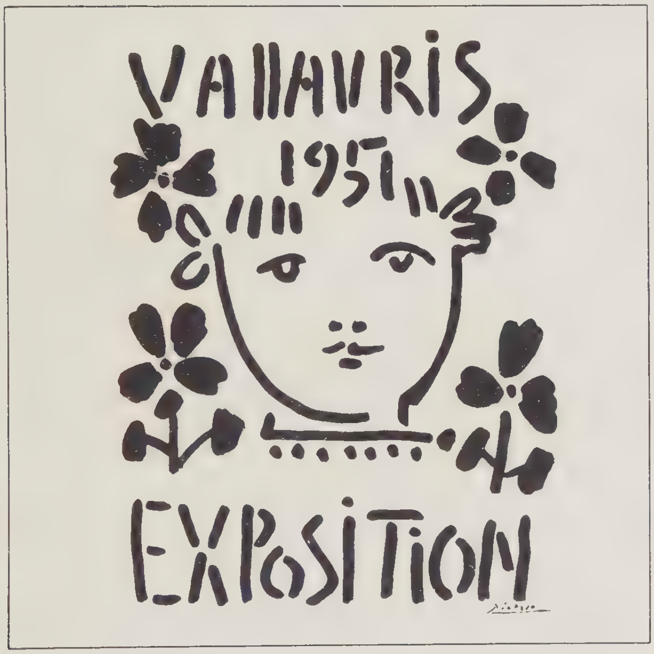
The many variations based on this and similar designs attest to the fascination the artist finds from the interplay of a great variety of color schemes and an extremely limited geometric format.



The kind of grid employed by Japanese architects in their traditional houses combines the virtues of determining the size of various rooms in the house, floors, walls, furniture, etc., and creating the style and appearance of the house. The Tatami, a straw mat approximately 3 by 6 feet and 2 inches thick, is the module or standard from which the plan of the house grows. Edward S. Morse, in his book, *Japanese Homes,* describes the mat system as follows: "The architect invariably plans his rooms to accommodate a certain number of mats; and since these mats have a definite size, any indication on the plan of the number of mats a room is to contain gives at once its dimensions also. The mats are laid in the following numbers: two, three, four-and-one-half, six, eight, ten, twelve, fourteen, sixteen, and so on."[13] This illustration shows the "plan" of a four-and-one-half mat room. Once the outer dimensions of the house are determined, the mats, together with the Japanese system of sliding doors, give complete flexibility in the arrangement and number of rooms. A perfect example of form and function, of discipline and play.

There are disciplines other than those based on geometry, among them availability of materials, reproduction processes, mechanical limitations, economic considerations, legal requirements, time factors, physical handicaps. Some of these are self-imposed, others are involuntary, but in the hands of the artist each may contribute to, rather than detract from, the end product.

It is inconceivable to consider Matisse's compositions with cut paper without, in some way, linking them to the play element—the joy of working with simple colors and the fun of "cutting paper dolls". But the greatest satisfaction, perhaps, is derived from creating a work of art with ordinary scissors and some colored paper—with so simple means, such satisfying ends.



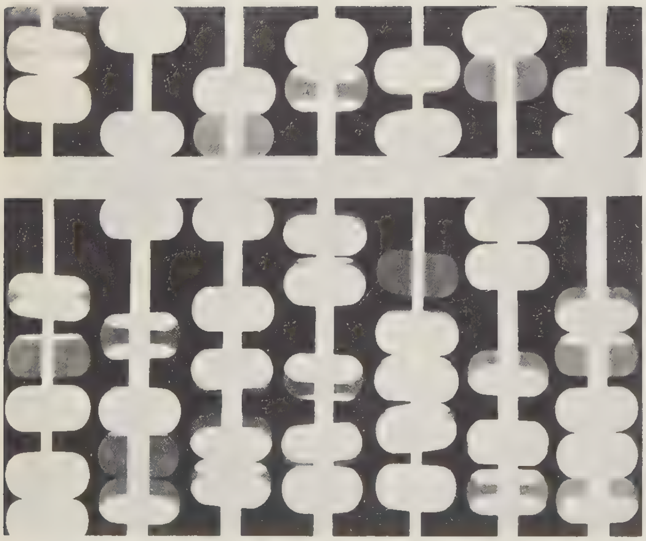
Similarly, the early Cubist collages, in which cut paper played an important part, are products of strict rules, limited materials: newspaper mounted on a surface, with the addition of a few charcoal or pencil lines, usually in black and white and sometimes with tan or brown or similarly muted colors. These elements were juggled until they satisfied the artist's eye. The playfulness and humor in the production of some of these compositions in no way detracts from the end result—a serious work of art.

One cannot underestimate the importance of restraint and playfulness in almost any phase of Picasso's work. Here, for example, one sees a restrained use of the brush and one flat color. The drawing of the child's face, the ornament and the lettering are all one. Lettering is not used as a complement to the drawing, but as an integral part of the drawing. It serves as both a garland and a verbal image—a visual pun. What emerges is a kind of game itself, revealing the ingenuity and playfulness of the artist, his ability to deal with problems in the simplest, most direct, and meaningful manner.

Similarly, this ability to do much with little—to find a bull's head in a bicycle seat and handle bars—is another aspect of Picasso's wizardry, his humor, his childlike spontaneity, his skill as a punster and ability to improvise and invent with limited, often surprising means.

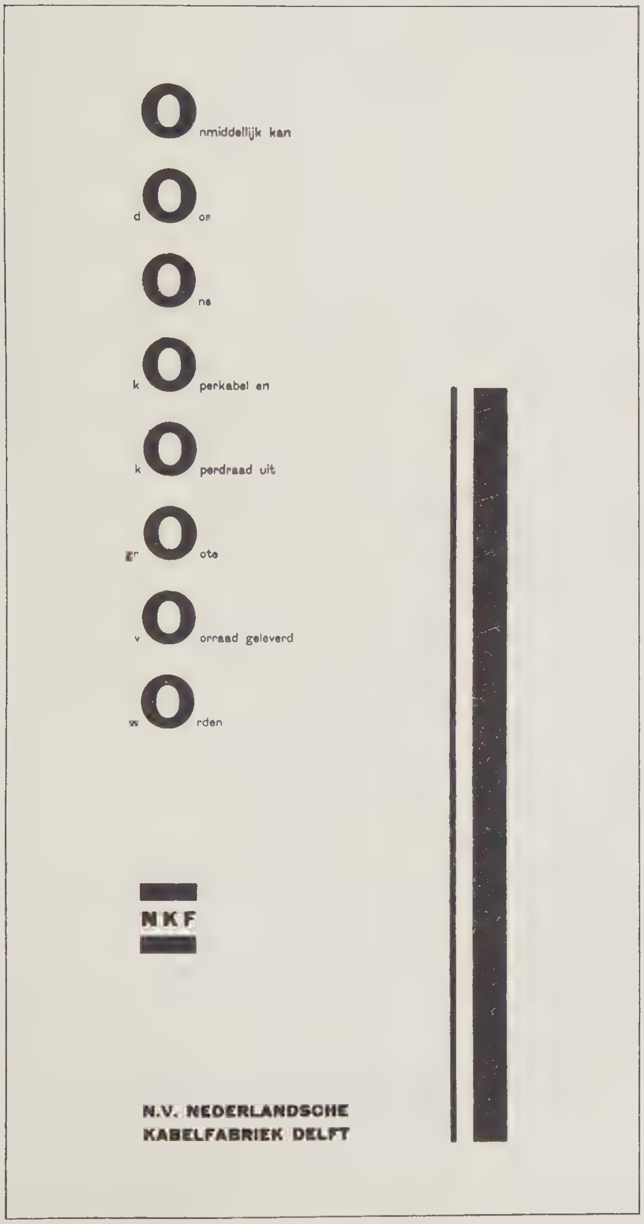
This monochrome, *Persimmons,* by Mu Ch'i, a thirteenth century Zen priest and painter, is a splendid example of a painting in which the artist plays with contrasts (the male and female principle in Chinese and Japanese painting): rough and smooth, empty and full, one and many, line and mass, black and white, tint and shade, up and down. It is a study in the metamorphosis of a fruit, as well as of a painting. (The artist, incidentally, never used any color but black.)

The reader may find a parallel, at least in spirit, between this painting and the preceding one by Picasso. Both employ a single color, and exploit this limitation to achieve as much variety as possible, and both undoubtedly were painted very rapidly, a condition often conducive to utmost simplification and improvisation.



In modern times artists like Man Ray and Moholy-Nagy, working with the most limited photographic means, the photogram, created highly significant pictures. This technique offers the artist ample opportunity to play with light and a great variety of materials, opaque, translucent, and transparent, to produce, very rapidly, rich and unexpected effects.

The photogram, at the left, made by the writer some years ago, shows how simply one is able to capture movement and achieve interesting tonal effects. Because the technique itself dictates a certain degree of speed the time factor becomes an additional discipline, which acts as a creative stimulus.



The *de Stijl* movement, founded in 1917, had a profound influence on painting, architecture, and typography. Piet Zwart, the designer responsible for this advertisement for the Dutch firm Nederlansche Kabelfabriek, was associated with this group.

The disciplines which *de Stijl* encouraged—functional use of material and meaningful form, and the restrained use of color (black and/or primary colors)—are evident in this design. With a few simple typographic elements and an ingenious play on the letter "O", a humorous, yet significant design was evolved. A picture is created by typographic means: a few type characters and type rules are so manipulated as to make a useful product, an advertisement. Many examples of this artist's work reveal this same playful approach and are worthy of serious study.

The earth colors of Africa, the ice of the polar regions, the bamboo of Japan, are among the many challenging materials with which artists and artisans create their idols, their utensils, and their houses—all natural limitations which provide their own built-in disciplines which, in turn, contribute to the creative solution.

Some years ago in Kyoto I was fortunate enough to witness a young Japanese craftsman make the "chasen" you see here. It is a whisk used in the tea ceremony and is cut from a single piece of bamboo with a simple tool resembling a penknife. Both the material and manufacturing process (about one-half hour) are the quintessence of discipline, simplicity and restraint. The invention of such an article could not possibly have been achieved by anyone lacking the ability to improvise and the patience to play with a specific material: to see the myriad possibilities and discover the ideal form.

It has not been the purpose of this discussion to provide a glossary of disciplines or recipes, but merely to indicate the virtue of the challenge implicit in discipline. "I demand of art", says Le Corbusier, "the role of the challenger . . . of play and interplay, play being the very manifestation of the spirit."[14]

1. Gilbert Highet, *The Art of Teaching,* Alfred A. Knopf, New York (1950), p. 194.
2. *Cahier de Georges Braque,* Maeght Editeur, Paris (1947).
3. Alfred North Whitehead, *The Aims of Education,* Mentor, New York (1949), p. 21.
4. *Ibid.,* p. 24.
5. *The New York Times Magazine,* December 15, 1963.
6. Chiang Yee, *Chinese Calligraphy,* Methuen & Co., Ltd., London (1938), p. 167.
7. *Ibid.,* p. 166.
8. Le Corbusier, *The Modulor,* Harvard University Press (1954), p. 55.
9. *Ibid.,* p. 80.
10. *Ibid.,* p. 101.
11. *Ibid.,* p. 63.
12. Matila Ghyka, *The Geometry of Art and Life,* Sheed & Ward, New York (1946), p. 120.
13. Edward S. Morse, *Japanese Homes,* Ticknor & Co., Boston (1885), p. 122.
14. Le Corbusier, *op. cit.,* p. 220.

VISUAL CONSIDERATIONS

From the most distant times, the human beings who inhabited the earth saw valleys, mountains, plains, and above them, contained by them and containing them, the immanence of the sky. They felt their bodies adhere to the sky and they took part in its life. Rain and melted snow, in loving struggle, dug ravines and river beds. Mountain tops touched the sky, and the sky was contained in the valleys, each taking part in the life of the other in complete embrace. Living things, both loved and feared, appeared to man, creating in him the need to communicate whatever impressed his pure and savage mind: the success of his endeavors, the allaying of his fears, the memory of his heroic deeds, and the exorcising of adversity. The light of the rising sun was a source of astonishment and joy, the lengthening of his shadow on the ground of wonder and fear, and the darkness of the night of bewilderment and terror. From the light upon the mountain, he came to know the day adorning, and from the mountain wrapped in darkness the approach of night. Thus it was evening, and then it was morning, and the rotation of the days and the stars gave man, his endeavors, and his life, regulation and measure. The asperity of rocks and mountains contrasted with the soft carpet of the valley and the running of the brooks. The alternation of daylight and darkness, the rising and setting of the sun, the regular ebb and flow of the tides, the rhythmic breathing of a living being gave him the measure of time and alternating movements, light and shadow in eternal contrast and in eternal development. From the most distant times, man has felt the need to understand the things around him, to give them order and meaning, and to find a relation between them and himself. From the darkness that precedes and the darkness that follows the weak spark of life, from the consciousness of the transitory condition of all living things, arises man's ardent and constant desire for certainty. It is forever present in him, desperately prodding him to search for ideas, concepts and symbols with which to endow his life.

From our earliest youth, we sense the fundamental laws of gravity, statics and dynamics, the behavior of solids and liquids, tensions, compressions, and torsions. Stored in our memory, this knowledge grows with us and accompanies us throughout our life. From our childhood we register and coordinate the different sensory perceptions of our surroundings in an effort to interpret our habitat and to explain the phenomena that puzzle us. I shall always remember the intense and questioning expression of a child who was not yet able to walk. He was leaning against a wall looking at the shadow of his hand. He wanted to grab it or to touch it, but, as he touched the wall, the shadow would disappear. After moving the hand in several directions, seeing that its shadow would follow and observing that this "other" hand had no substance, but still moved with his own, he turned toward the sun. He looked again at his hand in motion and the shadow following it. Then he looked at me with a happy and triumphant smile. I do not know to what point the child understood the phenomenon, but I have no doubt that he had an intuition of a relation between his hand, its shadow, and the sun.

A newly observed phenomenon must be logically and consistently integrated with the remembrance of previously observed phenomena. If an object falls to the ground unseen, it is possible from the noise it produces and from one's ability to connect the sensation of this noise to the recollection of previous experiences to determine approximately its size, the material of which it is made, its weight, whether it is full or empty, and many other characteristics.

The characteristics of the noise of a coin falling on marble might recall many sensations and considerations. A swift analysis of the noise calls to mind the size of the coin, the weight and value, the color of the metal, the shape, the distance and rapidity of the fall as well as the characteristics of the material, in this case hard, level and cold, upon which it fell. If we hear a new noise, a noise without counterpart in our experience, we will be uncomfortable and bewildered until we have found what has produced it. Only then will there be a lessening of tension and an acceptance of the new auditive experience.

Let us now consider one of the most important ways of perceiving: the visual one. Aside from its immediate practical value, the great importance of seeing is that it calls back remembered images and their emotional associations, and coordinates them with new perceptions as an aid in the formulation of new concepts.

No matter how complex are perceived images, the mechanism through which we receive and register them is relatively simple. The eyes first converge upon a point, focus on it and then scan in several directions (Fig. 1). Through this process we perceive images. Thus, we have the knowledge of full and empty forms, forms which are near and far, high and low, ascending and descending, and all the complex combinations which the eye finds and registers. All the images are coordinated and they reconstruct the world in its visual aspect. Slowly, the images detach themselves from memory and are transformed into visual symbols. In this way we acquire consciousness of a common denominator of perception and reaction, based upon consciousness itself and the constant verifying of the phenomena.

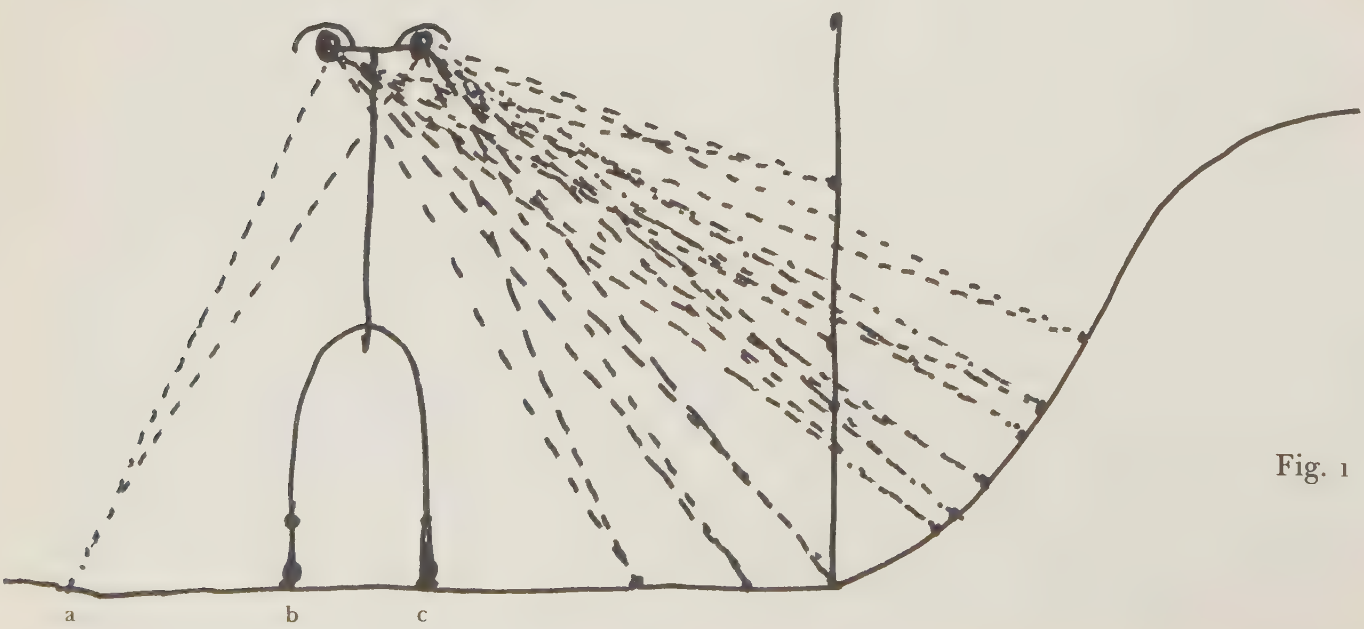


Fig. 1

Every person is a closed vessel, a finite organism complete in itself. Thus we can apprehend only our own experiences directly, but by transference from them we can understand the experiences, the joys and sorrows of others. Man then does not feel so fearfully alone in his world, and understands that the loneliness of each person can be partly lessened by reciprocal communication, which means each can participate in the events of humanity as a whole.

Throughout the ages, all civilizations have given enormous importance to visual communication because of its immediacy, its power of expression, and its lasting quality in time. Accents of color and symbolic forms, or simple ornaments of nature were used to emphasize the social function of an individual. Propitiating images and symbols were used in the rites preceding hunts or wars, and hunters and warriors adorned themselves with visible, mimetic or awe-inspiring elements, according to the functions they were performing. The visual medium of expression was an integral part of all social, political, and religious events. Idols, loved and feared, were venerated by all the members of the community; the presence of their images dominated their daily lives, acts, and thoughts. Heroes, leaders, great thinkers were glorified, and their images passed on to succeeding generations.

In almost all cultures, no matter how separate their origin, we may find parallel stages in the development and use of visual expression. We can induce from this parallel development a natural and gradual accumulation of common visual experience slowly developed into the form of visual symbols. Across long distances, through different latitudes and climates, and in different cultures, a mysterious tie seems to join man in a constant magic oneness, innate in him in every age. When man participates totally in life, this magic singularity is transmitted to the things he creates, whether idol or image.

Think of how an idea is expressed and read in words. An idea is expressed by word-symbols developed sequentially along an imaginary line (Fig. 2). The organized "coming together" of these symbols elicits feelings and ideas, evokes images, describes things and events. Like a magic thread running through time, these symbols have the power to recall an intensified world, to exalt or depress, to open new horizons, to induce understanding and love. The evocation of feelings through word symbols unfolds in time, as do the experiences of human life. Every synthesis, relation and conclusion is based upon evocations and remembered reactions, that is, a posteriori.

Fig. 2

Music too has its magic evocative development in time. Not only in a linear time, but also with echoes and tridimensional harmonies, since sound-symbols act simultaneously, dilating and expanding from the conductive thread of time (Fig. 3).

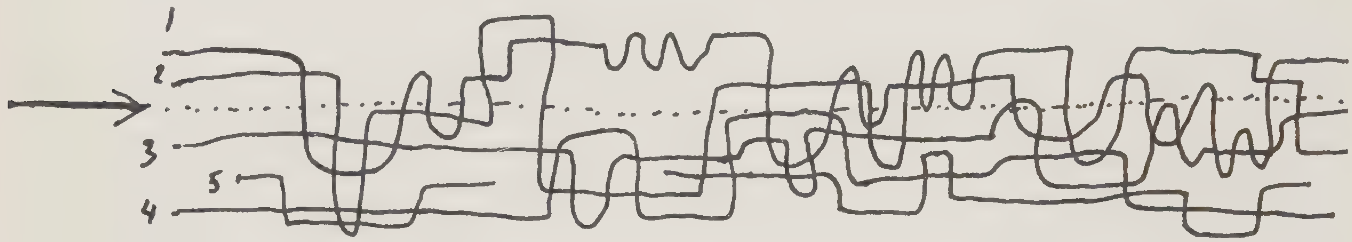


Fig. 3

The medium of visual communication, limited to visual forms and symbols which are objectivated and act in a space, has an altogether different reading. The emotive synthesis is not the result of an analysis of the different parts, but the reaction to a rapid consideration of the whole (Fig. 4). A second reading of the "particular" will begin almost as if to check the first emotion. Our eyes, like a flashlight that illuminates an object with its limited circle of light, examine the work in all its parts, tie in the motives, follow the trajectories and rhythms, acquire speed in the descents, mark the tensions and relax in the planes. The analysis of the work of art becomes an emotive reality in which we take part intensely.

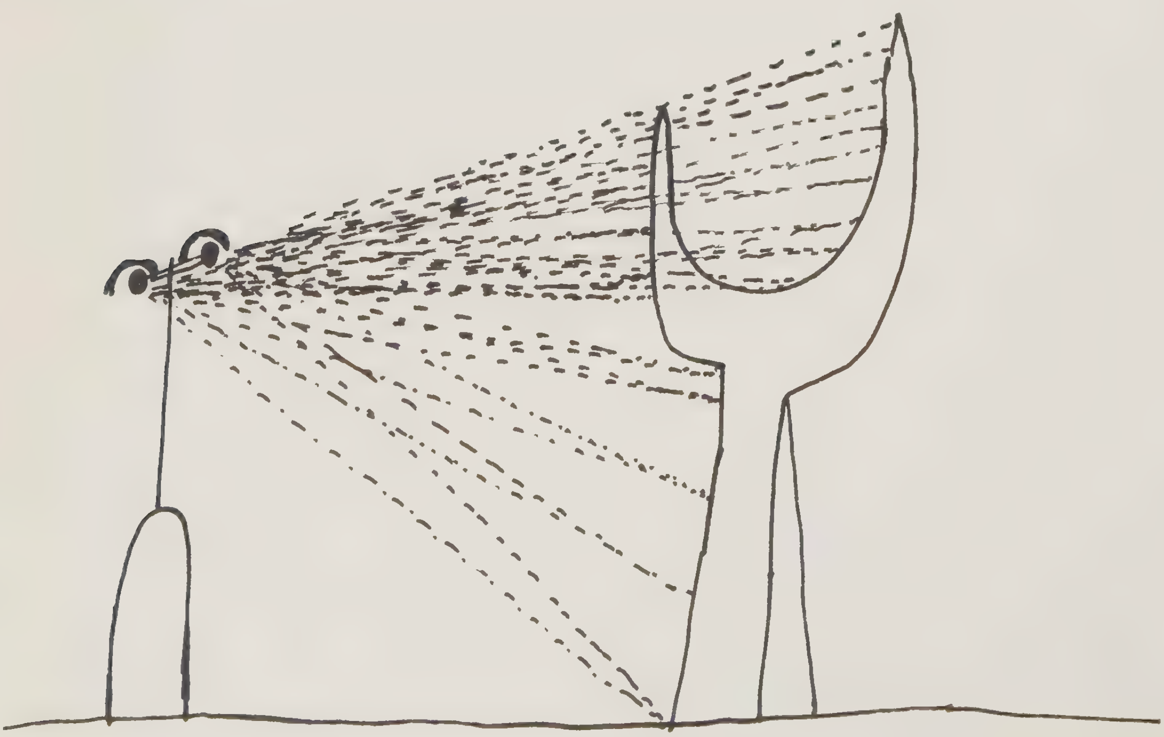


Fig. 4

Receiving the full value of the media of communication, however, requires a certain leisure and discrimination. Today the means we have at our disposal for gathering knowledge and the ease of global communications create an inflation of news and an inability to gauge its relative importance. We assimilate all chaotically, indiscriminately, and end with a confused and approximate *forma mentis*. Everything is brought to the same level. The same value is given to the most commonplace event as to the most inspired intuition or discovery. In this superficial and intellectualistic culture general information is fashioned after conventional and conformist ideas; knowledge is disenchanted, without participation. Better then, the true ignorance of the pure of heart! Contact with the universe all around creates in them wonder and fear, exaltation and depression, but always by direct contact, without the interference of a false culture. They are cheered by the appearance of the morning sun and moved by the sight of a flower in the meadow, while the disenchanted well-informed man knows everything, and for him everything which is known is discountable. He already knows that the sun rises every day and that flowers grow in meadows. The "well-informed" of today has lost the magic sense of life. He is incapable of that love through which man forgets himself in total participation in an existence beyond the human dimension, beyond time and space, in cosmic communion.

Present day society tends evermore toward a rational mentality, organization, and character. Everything is brought to a focus, circumscribing and limiting man by specialization and rationalization. The impulsive and fantastic element inborn in human nature is repressed and atrophied, and man with ever growing anxiety feels constriction and a lack of personal autonomy resulting in a sense of depression and uselessness. The necessity of being ever conscious and aware of unimportant details leads to the dissipation of the basic human drives. Astonishment before the marvels of life is smothered; every impulse is thwarted, considered harmful to organized society. The unforeseen, the stupendous emergence of things, and the magic sense of life, are judged, emptied of their worth, and discarded. The unconscious side of ourselves is the half of our being in the shadow, and cannot be undervalued without seriously maiming an important part of our complex human nature.

The sense of bewilderment generally found nowadays in the works of contemporary artists, and the lack of religious feeling—religious in the widest sense of the word—are in great part due to the impossibility of accepting the ideals and the fallen gods which formed a bond between the artist and the community. After destroying temples and gods, conscious men could no longer rebuild upon the same bases. The magic circle was broken and the answers given to unanswerable questions no longer quenched their thirst for truth. Without the transcendent link which tied man to the gods, and with the dismemberment of the community, the condition of the more enlightened human beings was at the same time more desperate and more fascinating. Everything had to be newly built upon the primordial bases. It was necessary to find direct contact with existence, to understand the internal process, the prime reason of things, and the laws governing them, and not to limit oneself to the external appearance of the visible world. . . . And things took on a new dimension: man divined new spaces and times, and measure was no longer the only unit of measure. Science proved that reality is not what we perceive, but that through our limited perception we create a relative concept of reality. To crystallized ideas, to conventional beliefs, and to the ideal concept of beauty, the modern artist opposes the investigation of visual phenomena, a greater understanding of the world, as well as a greater potentiality of his medium of expression.

Ours is the epoch of great researches. New dimensions and relations are being explored, distances are being shortened, people and civilizations of different origin are being brought closer to one another. There is therefore a need for understanding, for a new redimensioning based upon common human denominators; and in the arts, a need for a common visual language. Visual expression is an intrinsic part of society, and its emanation; it can only exist, therefore, in its own time, expressing it. An idea expressed in words can be intuited or thought only by using the symbols of words; in the same way, in the formulation of a visual idea, symbols of a visual order are required. They must be used logically and in a precisely organized system which relates to the actual visual experiences, as well as to the experiences of the other senses. "But the idea, in being realized by the artist, must overcome the resistance of the material. The embryonic idea, accompanied by the baggage of preceding experiences, will be contrasted in its development by the material, passive but with its own properties, physical laws, and visual appearance." (Paul Klee, *The Thinking Eye,* New York, Wittenborn, 1960.)

Like all forms of reading, visual reading requires a passion and a tension for which most of todays' readers are not prepared. The reader should integrate the work of art, taking part in its travail, collaborating, responding to its stimulus. The reader must participate actively in the allusions and suggestions. The task of the artist is not to describe the visual appearance of the world surrounding him, but to consider the visual aspects which derive from this world. The reader, or interlocutor, must collaborate actively in the completion of the visual suggestions. But, with the exception of a few with particular sensibility, of some initiates, or specialized professionals, our society is so very little trained in seeing as to be almost blind, being accustomed primarily to literary representations.

Basically, in perceiving an object you see only its form and color. For the perception to register in one's mind, it must relate to previous perceptions, to a concept of its essence. Otherwise, it is as if we had not seen it, for our memory will have retained no trace of it.

As we observe and experiment with the world around us and the repetition of its phenomena, we infer the existence of a phenomenological world. From the interrelation of these phenomena, we formulate the concepts we have of them. These concepts are the basis of our mental-visual formation, and they condition our thoughts and our imagination between "memory and vision, recall and anticipation, recovery and foresight".

The concept of space-time considered as cubic space of the perpendicular meeting of the three straight lines shall be measured with the time and psychic effort employed in covering the distance between one and another point. Space and time are superimposed into a single idea of subjective measuring. The time it takes a stone to fall from the top of a mountain to a valley gives us an emotional sense of the distance of the fall. The trajectory of a thrown object is a parabolic curve and its visual measuring gives a sense of emotional participation through time. The space becomes a feeling of space-time in its visual measuring.

Two fundamental directions prevail over and condition all our lives. Every falling body follows a vertical course toward the earth and every tree stretches in a vertical sense toward the sky. Man lives in a vertical equilibrium of activity. On the other hand, all liquids tend toward a passive horizontal equilibrium. Man and beast rest horizontally.

The continuous interdependence between these two fundamental lines dominates our perceptions and actions. The active vertical and the passive horizontal, coming together in a focal point, will create a concentrated energy. They complement, oppose, and unavoidably unite with each other.

Forms, colors, and spaces, organized with the logic of the appearances of reality, give meaning to such appearances and intensify their evocation. Empty spaces alternating with full ones become a rhythmic allusion; visual symbols recall sensations and images of life, allude to compressed or dilated spaces; and lines acquire energy. When symbols are brought together, by contrast or by sympathy, they acquire harmonic or dramatic meaning, dilate dynamically and increase the expressive tension.

Let us consider a circle and a horizontal in a limited space. These two elements acquire a particular meaning according to their position in this space. Our mind tries to connect the circle to images previously perceived and stored in our memory, such as the sun, the full moon, a ball, and all other circular images. Then it considers the horizontal element and ties it to the memory of horizontal images. From the horizon of the sea it goes to the infinite stretching of the fields and, in a general sense, to both the remembrance and the concept of horizontality. Beside these general allusions of circle and horizontal, their relative positions call to mind other sensations and ideas. If the circle is near the top of a limited space, such as a page, and the horizontal near the bottom, our eyes measure the distance between them and, as these symbols have evoked horizons and celestial bodies, this distance seems enormous, greater than the actual space between them, and relatively greater than the spaces between the symbols and the upper and lower limits (Fig. 5). There is a magnetic emotional attraction of the horizon toward the lower limit, and of the circle toward the upper one. The emotive meaning suggested by the two symbols will be of passive, compressed stasis for the horizontal element and of a dynamic, uplifted sense for the circle, in a feeling of relation and unity. If the circle and the line are placed differently, though the particular evocation remains, the relation and consequent feeling will change. If we displace the two symbols, putting the circle below the horizontal, there results a sense of suffocation (Fig. 6). Space will seem compressed between the horizon and the upper limit, and the circle will seem to have fallen below the horizon, giving a sense of depression. Thus the feeling about the symbols is affected by their relative positions and, of course, the addition of other symbols will widen and render more complex the emotive suggestion.

Fig. 5

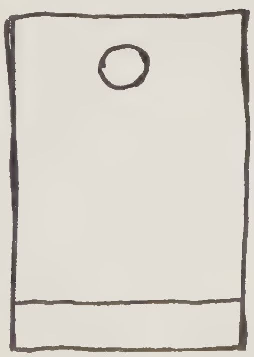


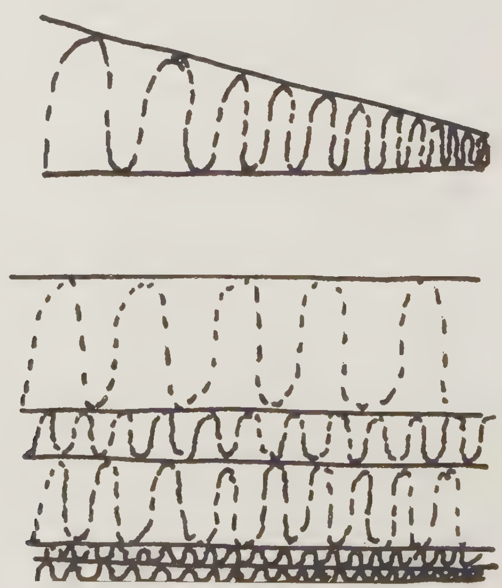
Fig. 6

One could go on at length analyzing the evocations stimulated by the same symbols in the infinite combinations possible among them on the basis of the relations of the placings and the spaces, of the relation between the visual manifestations of physical phenomena and the equivalent allusions. We could also consider tensions, torsions and directional energetic forces: the evocation of feelings through combinations of forms, colors, transparencies, reflecting materials and movements. And with these we might combine in controlled ways natural elements like wind, water, fire and sound. These considerations would take us even farther and would open the way to wider researches of visual studies, to new possibilities and realizations.

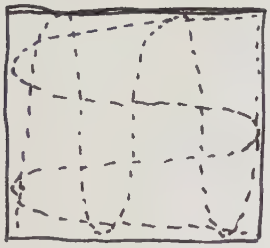
In closing, I think it is well to emphasize again the difference between the conventional way of describing objects and symbols by literal representation, and the poetic evocation of vision through equivalences of knowledge suggested by the reality surrounding us. There is nothing more false and more unreal than a representation of reality if this does not become a reality of equivalence, autonomous and independent from reality itself. "Every attempt to remake reality tastes of folly."

Today, not only artists, but men in all fields have come to recognize the efficacy and importance of the visual medium as a mode of expression. Many studies in the various areas of communication have been made. But an exhaustive unified theory common to all visual experience is lacking. Nor is there a scientific formulation of the fundamental principles of a visual grammar and syntax. There is a deeply felt need to state the problems and to clarify the basic concepts common to all forms of visual expression. There is a need to gather the theoretical, experimental, and artistic results thus far obtained, and to clarify and articulate them into a comprehensive theoretical formulation.

In the last few decades new symbols have been added to the existing visual vocabulary and new materials have created new ways of expression. Light and moving images have freed the observer from the conventional way of seeing. This new vocabulary and its consequent reorganization of concepts will contribute to modern culture a new potential and a richer understanding of visual expression.



Figs. 7a, 7b.
Two straight lines close to each other create a sensation of magnetic attraction. The space between them creates a feeling of energy measured by the distance between the two lines.


a

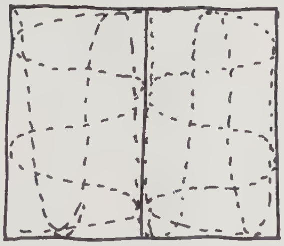

b

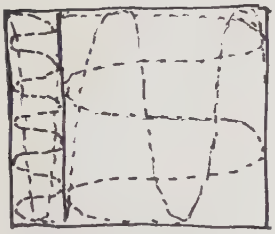
Fig. 8.

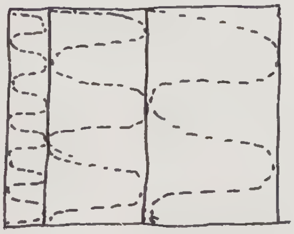
a: A closed space creates within its limits a sensation of energy.

b: Dividing a closed space into two equal parts creates two equal forces.

c: Dividing a closed space into two unequal parts creates two unequal forces. The larger space appears to push in the direction of the smaller.

d: Dividing a closed space into three parts of diminishing size creates a direction of forces from the largest to the smallest.


c


d

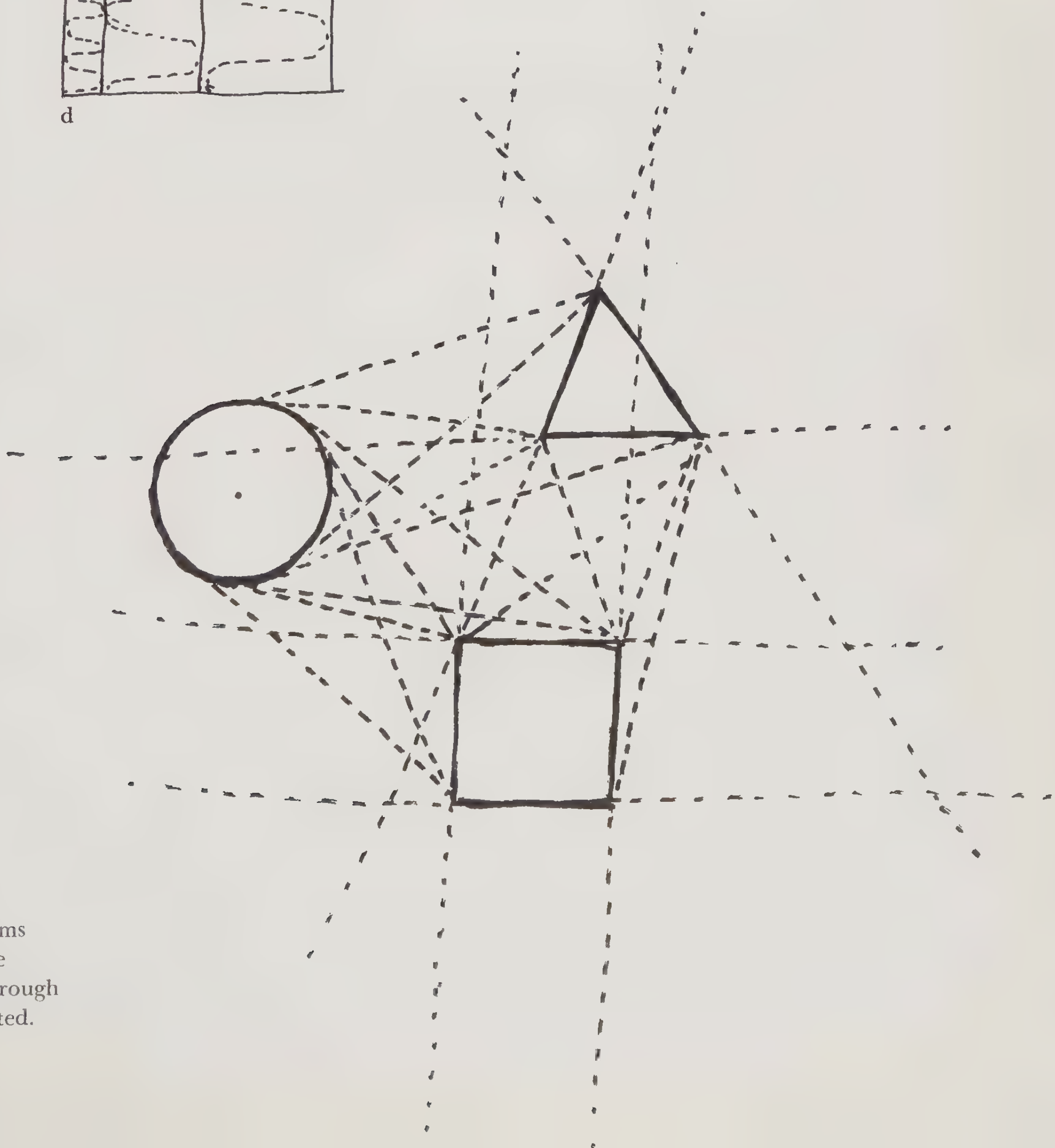


Fig. 9.
The lines of geometric forms in a two-dimensional space are potential indicators through which these forms are related.

JULIAN BEINART

VISUAL EDUCATION FOR EMERGING CULTURES: THE AFRICAN OPPORTUNITY

Since the time when the known world was that bordering the shores of the Mediterranean, European man has been accustomed to the idea of expansion and the absorption of alien cultures. Colonization was a machinery for keeping this concept alive: by means of colonization Europe transplanted its own institutions throughout the world and in turn brought back material for its own growing culture. The virtual end of colonial empires has not broken down this process, it has merely changed the rate and the scope of the interchange. On the one hand, many former colonies, now independent nations, are receiving a vastly accelerated influx of material goods and ideas, and undergoing rapid changes in a long-established way of life. On the other hand, what these emerging cultures will feed back depends almost entirely on how they come to terms with these changes. Pessimists believe that imported culture will inevitably destroy native ability and produce a sterile imitation. A more hopeful view sees in these changes the opportunity for a fertile fusion of old and new and the future export of an original and alive product.

Nowhere have the changes been greater and faster than in Africa. In 1950 there were four independent states on the continent; today, twelve years later, there are twenty-nine. Of the history of the peoples of Africa little is known; of the history of their art even less. What is the future contribution of these peoples to be, and more specifically, what art are they likely to produce? It is part of the purpose of this paper to show, by gaining insight into the potential creativity of these people, that pessimism is by no means justified; one hopes in this essay to indicate how, by establishing goals and a few methods, any future education in the visual arts might release and direct this potential.

The continent of Africa is large, four times the size of the United States; the 200 million people speak over 800 languages; at a conservative estimate there are over 2,000 tribal divisions. What justification is there therefore for talking about Africa as one unit, in the way that President Nkrumah claims that "from Tangier or Cairo in the North to the Cape in the South, from Cape Guardefui in the East to Cape Verde in the West, we have one Africa indivisible"?[1)]

This concept of one Africa is maintained from two clearly different points of view. The first treats Africa as an autonomous entity, distinguishable from the rest of the world. Thus creative writers have coined new words such as *négritude* (Césaire) or, more particularly, the *African personality* (Blyden), in an attempt to summarize what being an African has meant in the past and what it means today. The search for such symbols indicates the need to express the uniqueness of an African identity as opposed to any other. The second view of one Africa finds it possible to treat the continent as a whole without having to isolate it.

In the visual arts there are few people searching for a specific African character. This might well be because there are so few working in the visual arts in Africa; when their numbers increase, there will perhaps be an effort in this direction. However, unlike the literary tradition, which is new in Africa, the visual tradition goes back to the very roots of tribal societies and religions, and reveals the universal characteristics of tribal art rather than any particularly African qualities. William Fagg, talking about the similarity of tribal religions, says: "Some form of dynamism appears to be common to all or most of the indigenous religions of Africa, but this does not mean that dynamism is an African phenomenon: rather it is a tribal phenomenon and is shared by the African peoples with the peoples of Borneo, Assam, New Guinea, Australia, Polynesia, America, and probably with all the tribal and prehistoric peoples of the world. Therefore it does not provide the basis for a *specifically* African personality. . . ."[2]

Furthermore, the changes which have taken place to alter the tribal situation have not been limited to Africa alone. In many other parts of the world, people who for centuries have remained largely rural and agrarian, contained within the circumscribed framework of a tribe, have been introduced relatively quickly into a more urban and industrialized, less defined way of life This has posed problems and raised issues which are not yet different enough between various parts of Africa to invalidate the concept of its being regarded as a whole. As a result, the problems raised by these changes in Africa are not so different from other developing areas as to render inapplicable to those areas as well the particular cultural observations to be made in this paper.

The changes in the tribal context have had profound effects on the visual arts in Africa. In the African tribe, as in so many other societies, religion—used here to include all socio- or magico-religious activities—was the major impetus for artistic creation. With the displacement of traditional religions by others from East or West, the religious artist has suffered a complete disorientation and loss of artistic purpose. Where traditional religions survive, ritual objects are still made, but little remains of the intense involvement that found expression in the highest forms of African plastic art. New religions have not as yet been able to provide sufficient incentive for the artist, and only in rare cases has an inspiration similar to that of the traditional religion been applied to the making of works for the new religion.

The artistic act in itself has lost its previous significance. Concerning the importance of the act of creation in the making of religious sculpture, Ulli Beier has written that the creation was a sacred act rendered unto the god, that the made object was invested with less importance than the act of making itself, and that there was no desire to preserve the object when it was threatened with destruction—its destruction merely being an incentive to make new pieces.[3] Beier points out that this was an attitude which kept the art alive instead of prolonging the life of the object. The tribal environment was in itself a living and constantly changing display of art. With the change of art expression from "religio-social necessity to politico-social and educational needs", as Ben Enwonwu, the Nigerian artist, suggests,[4] the new African society has found it necessary to build museums to preserve and restore.

The tribe was a relatively limited and self-sustaining body, and provided the artist with a frame of reference which guided his output and supplied him with subject material but never deprived him of his liberty as an original creator. He was "a distinguishable and original personality, just as much as Cellini or Turner or Matisse". Tribal influences were the "framework within which the artist must work and create" and were not any more "restrictive of genius than were the conventions of religious art in Renaissance Italy".[5] Today, in a state of rapid economic development where hydroelectric schemes and mass education are among the society's priorities, the artist no longer enjoys such a fruitful relationship with the public. Tribal man was closer to the sources of creation and so had a critical appreciation not possessed by the new middle class, which is confused in a search for standards of judgment. In Africa the idea of the professional critic is a new one.

Changes have left the religious artist with no inspired purpose, no creative framework and no critical public, and he can no longer survive. He is being replaced by people whose work is fulfilling new needs felt within the society: the anonymous craftsman, for instance, who, much like his counterparts from Lourdes to Tokyo, turns his skill—but little else—to the production of objects to satisfy the indiscriminate tastes of the tourist market.

The art of tribal Africa does not only consist of work dedicated to religion. It includes a wide variety of other objects made for everyday use, ranging from carved wooden headrests to bronze weights and woven textiles, products of a developed craftsmanship and an acute sensitivity. Machine-made goods and a cash economy have slowly reduced the need for these tribal products. Today cheap plastic basins can be used instead of terra-cotta pots, machine-printed cloth instead of handmade batiks.

One would expect that, since industrialization is occurring in Africa and other developing areas later than in the West, Africa would have the advantage of benefiting from previous mistakes. However, this seems not to be the case.

Nowhere can this be seen better than in the industrialized economy of the city. The city concept is not new to Africa. Contrary to popular belief there have been African cities in the past, cities like Great Benin, described by a Dutch traveller at the beginning of the seventeenth century as having a "main street seven or eight times wider than the great street of Amsterdam".[6] The African city of today, however, is different. It is growing into a permanent center of vast population, of supermarket and cash sale, of air-conditioned offices and congestion; and this kind of city is becoming the hub of a new metropolitan distribution of population.

While many people outside Africa are wondering how satisfactory this type of city is, in Africa it is being welcomed. The people there are eager for the cars, the noise, the parking lots, unaware of the problems that these have created in more established situations. As a symbol of progress, cars are synonymous with advancement and new status, just as are the skyscrapers erected indiscriminately among shacks in tropical climates. That there is a city in Africa which in its publicity brochure shows a peak-hour traffic jam as evidence of how up to date it really is, is not an apocryphal tale.

The problem of learning from the urban mistakes of the established world—or for that matter from any other precedent—is unfortunately not an easy one for developing peoples. There is little time for planning, as the country must go ahead rapidly; people are demanding what has been withheld from them for so long, and politicians only survive if they can satisfy the need.

What I have described are a few important features of a complex transitional period, in which people are faced with choosing between what to retain of an old way of life and what to accept from the range of vastly different substitutes now available. The choices are seldom clearly stated or easily made.

This view of developments in Africa seems very dark indeed; and many will unfortunately stop at this point. They will say that everything traditional from Africa is good, everything new, bad. They will enjoy the contemplation of the past, forgetting that Africa moves ahead, and no one in Africa can, and very few want to, go back. There is too much to look forward to, there are too many opportunities; too many things are happening for the first time.

There are, however, aspects of this situation which are more encouraging and which can easily be ignored or overlooked when the position is regarded from a prejudiced point of view. Three of these aspects I feel are extremely important and can suggest goals and teaching methods in the visual arts in Africa.

I. While a new African society can no longer produce tribal art, it has not completely lost the creative force which generated its traditional art. African people, by retaining their innate ability and adapting it to new circumstances, have invented a folk art different from the folk art of the tribe. This is a new popular art, produced for an urban proletariat by anonymous artists, who have found outlets for their creativity in new needs and new media.

On the east coast of Africa, on the outskirts of the city of Lourenço Marques, people live in shacks built of plaster, reeds and corrugated iron. There is a story that when the President of Portugal visited the province a few years ago, his route took him past this area and the inhabitants were given paint and told to improve their houses. In the same way a Bushman might have painted the people and animals of his daily existence, these people painted men, animals, flowers in pots, or symbols of their own houses. The drawings were done with the greatest economy of means, just enough drawn to show what was intended—the turn of a line changing it to leaves, a narrowing of a shape turning it into a fowl. These are diagrams of forms: men with square bodies, circles for heads, lines of framed constructions, all done with a simplicity and innate sense of visual form unhindered by conventions about what these things should look like. (Fig. 1)

Fig. 1. Wall of a house, Lourenço Marques, Mozambique.

It is probable that these people had never painted before, and one doubts whether they ever would have painted their walls without encouragement. Possibly they could not afford the paint, but it seems much more likely that they merely needed the incentive. Whatever the reasons, they were able to give their own decrepit structures a sense of importance, an identity to separate one from the other. Along the streets of Levittown, on the other hand, when there is a desire to preserve a personality in the face of thousands of identical neighbors, all that is left on the inhabitants' palette is the choice from a catalogue of pseudo-Colonial, Cape Cod or "modern" decorations. Here one wonders how much is left of any personal creativity.

Wallpainting occurs in many parts of the African continent today. Where it is an old tradition, recent conditions have provided opportunities for new drawings and painting. Near Aden, a Middle Eastern wallpainting tradition continues with different subject matter inspired by contemporary events. In the village of Al Waht, apart from geometric and floral designs, walls are now painted with "all kinds of fantasies as well as aircraft, radio sets, kettles, coffeepots, 'diabolo men' and windmills."[7]

In the northern Sahara, a Boston bomber which crashed during World War II provided a chance for unknown Tuareg artists to draw on its fuselage. These drawings of camels and riders are new versions of traditional rock drawings and carvings which date from many centuries earlier.[8]

Sometimes a new medium has given rise to a new form of expression. In Nigeria cement is a relatively new material, which sculptors have used to make decorative lions. These lions with their tails flapping over their backs often embellish house balconies or stand side by side on carved tombstones. Sometimes they face each other over entrance doors which are themselves carved and which sit in molded plaster surrounds (Fig. 2).

Popular art is often produced as the solution to a need which is new to the society. Where people before might have built up a rhythm of beads or lines on a calabash, a new cash economy suggests improvisation on a very pertinent theme, the £.s.d. sign in western Nigeria, which they repeat and invert in cement as balustrading to a balcony.

In the new economy, trucks are valuable possessions. Wishing to endow these with a personal stamp or to advertise them, or perhaps to ask for divine protection, people produce drawings and inscriptions on their vehicles which are the personalized versions of the Coca-Cola signs or St. Christophers of the West.

The cinema is a new means of entertainment. It requires advertising and before the lithograph press arrives, someone has to improvise. Ulli Beier has shown a superb example from Nigeria of a cinema advertisement drawn in chalk on a blackboard.[9] Somewhere between this drawing and the superspectacular poster which adorns the highways of the industrialized world, something has changed and something has been lost.

Fig. 2. Cement lions on a house balcony, western Nigeria.

II. While the city is bringing new problems to Africa, it is also affecting African culture favorably. Urbanization has brought contacts which, although precipitating years of unresolved political conflict, notably in southern Africa, have also had constructive results. The learning process of the immigrant people has been quick and productive. In some cases, post-tribal people have learned to use a medium completely new to them and have infused it with their own inherent sensibility; in other cases the melting pot of the city has allowed them to revitalize tribal forms which were in danger of dying away and which new stimulus has transformed and kept alive.

The southern Ndebele people live in the country close to the densely populated goldmining belt around Johannesburg in South Africa. When they first made contact with white settlers, some hundred years ago, they started painting the walls of their huts (Fig. 3), showing the superb architectural understanding characteristic of their work.[10] Wallpainting became a new outlet for their innate sense of design, a sense which they exhibit in their clothing and beadwork. When they came into contact with the urban environment, the Ndebele, like the Aden artists described earlier, combined geometric patterns with new images. These were images based upon urban forms—public buildings, light-fittings, peanut advertisements—done mainly with earth colors but sometimes also with artificial pigments and bright Reckitt's blue.

Fig. 3. Interior wall of a Ndebele hut, Transvaal, South Africa.

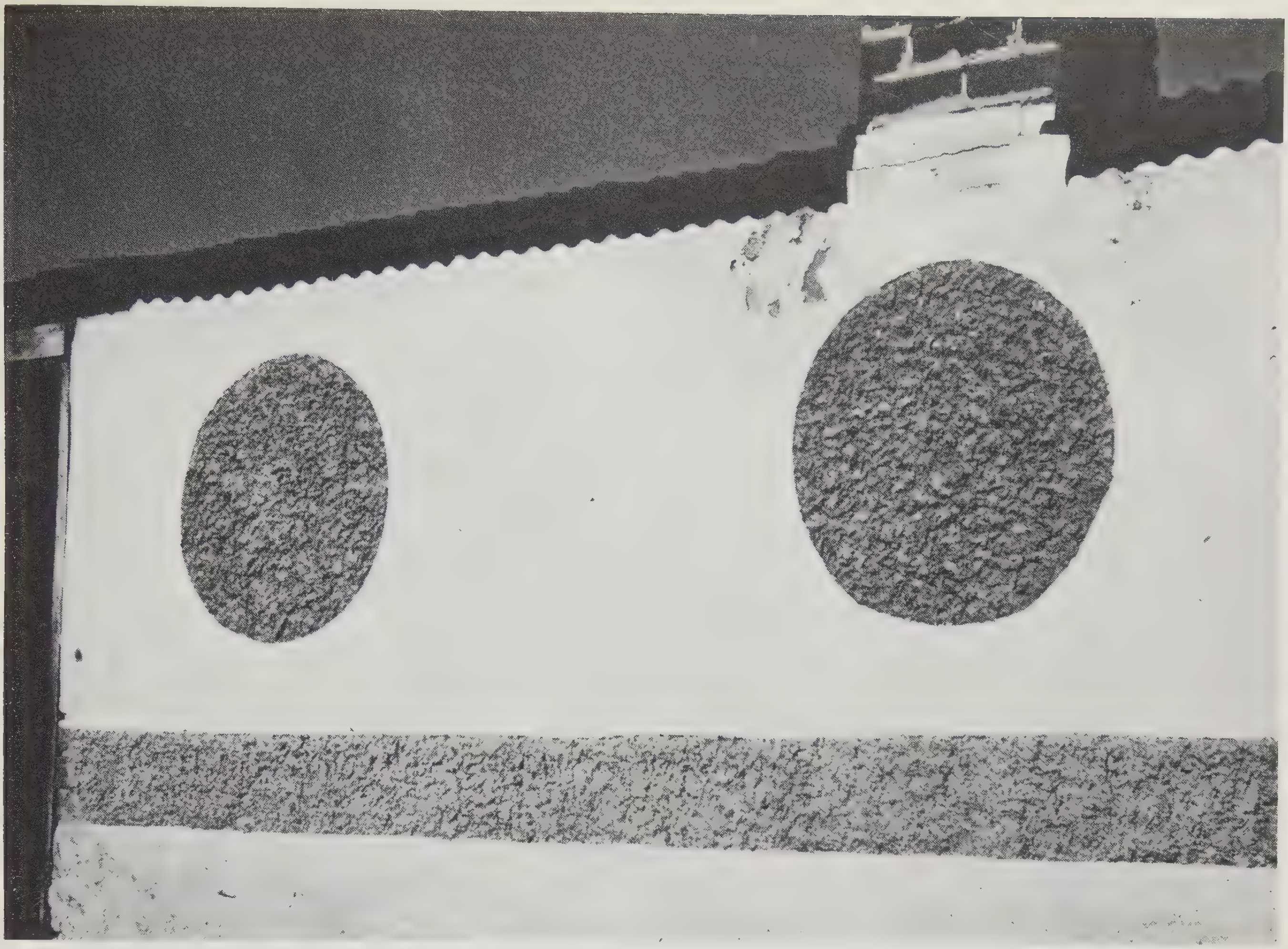


Fig. 4. Wall of a house, Western Native Township, Johannesburg, South Africa.

Many of these Ndebele people have left their rural homes and infiltrated the large metropolitan area to their south. Here—because of their color—they are, with hundreds of thousands of other African people, segregated into residential townships. These "locations" cover square mile upon square mile, endless stretches of identical small box-houses, which remain blank and unimproved, the new wastelands of culture separation. Nearer the city center, however, in one of the older townships, Western Native Township, the houses are more decrepit, the roads have deep potholes, and facilities are few. Here almost every wall facing the street has a painted design and almost every house an added porch, devised from old pressed-metal ceilings or wooden lattices. Trees grow and life plays in the streets.

Even though the inhabitants of these houses will soon be relocated to the outlying areas, they have tried to improve their environment. Their walls are painted with a few, bold elementary forms which cover large parts of the façades of the one-story houses. Two large orange circles and one broad base strip constitute a complete façade of one house (Fig. 4); on another there is only a circle with stripes radiating to the corners of the building, much like a rising sun. Sometimes the forms are less regular, shapes like the map of Africa on which the house number is painted in the place of the Sahara Desert.

It is difficult to find origins for these paintings; the forms have little to do with insistent tribal rhythms. At times it seems that the designs might be developed from the shapes of urban buildings, quoins at building corners for example, or the fat precast cement balustrading that can be seen all over suburbia. The boldness and simplicity of these abstract forms, however, indicate originality rather than eclecticism. These walls and porches reveal again the desire and ability of African people to decorate in a creative and personal way; here the city has provided the milieu for them to do this.

Fig. 5. Painting by Valente Goenha Malangatana: *The Abyss of Sinners.*

The visual examples from the city are not as striking as the musical examples. Upon a rich tradition of folk music, African people in the metropolitan areas, especially in South Africa, have built a wide range of urban music—dance, jazz and the beginnings of an art music. With the simple penny-whistle from the factories of the British midlands, young Africans blow their own rhythms; when they cannot afford a fiddle, they invent a tea-box bass. Previously they sang for ritual or work; now they sing their own popular songs, often versions of imported pop tunes. Rock-and-roll inspires the "kwela". They learn English and mix it with their own languages to produce word textures in song. They study the intricacies of saxophones and trombones, listen to American records and then produce their own jazz. The achievement of this large and ever growing body of music testifies to the powers of the city to receive different elements and produce new life.

III. Among those replacing the religious artist of the tribe, there are young people who are trying to face a new artistic existence without renouncing their past as worthless. For these, the new post-tribal frame of reference, an international patronage, and the new range of techniques and ideas are accepted as part of the challenge to artists everywhere today; but, unlike many others, they benefit from a heritage which is still very close.

Ibrahim el Salahi is one of these artists: he was trained overseas, and, among other themes, has been preoccupied with the Arabic calligraphy of his native Sudan. Of the young Nigerians, painters like Demas Nwoko and Uche Ukeke were trained in their native countries and use their own regional background in their work. A preface to a recent exhibition of their work says of them: "While they have acquired modern techniques and work in a modern context and for an international public, they still seek inspiration from the rich folklore and art of their native Ibo culture. There is no question here of a cheap perpetuation of Ibo tradition however . . . [they] are interpreters of contemporary Nigerian life . . . and have been able to recreate some of the depth of feeling and dramatic tension that we associate with Ibo masks."[11]

In the South, neither Sidney Kumalo, a South African sculptor, nor Valente Goenha Malangatana, a twenty-five-year-old Portuguese painter and poet, have had any formal training. Malangatana, who has been painting for only three years and writing poetry for even less, was born in the bush country near Lourenço Marques, the capital of Mozambique. Writing about this country and the skill of the women there, he says: "Even after they were married they continued to do ornamental work, which is usually done with beads on calabashes, belts for women and men, wide necklaces for women and babies, and also bracelets made of beads for witch doctors. My mother not only knew how to do this but also how to sharpen teeth . . . besides this, she did tattooing on stomachs and faces. She used to make sewing thread from pineapple and sisal leaves."[12] Malangatana's paintings show the complex interwoven influences that have been part of his rural and later urban life: his youth among witch doctors and madness and his contact with Catholicism and Portuguese European life. His early paintings deal with simple tribal stories or events in the city; his later work has become less narrative, depicting scenes of violence and death. These are obsessive paintings of dismembered bodies, blood and dripping teeth, pulsating forms which Malangatana manipulates on big canvases in strong, compelling colors (Fig. 5).

He frequently writes stories to accompany the paintings; often both painting and poetry treat similar themes, as in this stanza translated from the Portuguese:

Woman's hair shall be the blanket
Over my coffin when another Artist
Calls me to Heaven to paint me
Woman's breast shall be my pillow
Woman's eye shall open up for me the way to Heaven
Woman's belly shall give birth to me up there
And woman's glance shall watch me
As I go up to Heaven.[13)]

Malangatana's paintings are interpretations of a way of life in which mysticism and fantasy play a large functional role. Although there is a temptation to call his paintings Surrealist, his vision is for him straightforward and real, unlike the intellectual game that it is for many sophisticated European Surrealist painters.

He is one of a new generation of artists who are beginning a tradition which bridges gaps between old and new, country and city, culture and culture. When Malangatana paints pagan witch doctors with Christian crosses around their necks, or African women with long flowing hair, he may be showing that these gaps are not so great that they cannot be crossed; and that the value of a work of art is to demonstrate universal qualities instead of the specific peculiarities of small groups.

Were the fragments which I have described only the products of a long development and not the first physical results of a transition, there would be little point in talking about and having faith in the future of education in the visual arts in Africa. The cement lions, the wallpaintings, the young artists all show that something new is coming out of the complex processes of change that are taking place in Africa. Instead of trying to frustrate this change, or smothering the still young signs of emergence, it seems much healthier to be grateful for these and to accept them as the basis for a living educational attitude.

The first aim of teaching in the visual arts in Africa should be the continuation and expansion of a strong folk tradition. Where a still valid tradition has been destroyed, teaching can attempt its resuscitation; where traditions have continued or where new situations have produced spontaneous solutions, teaching can demonstrate their value and build on them. Teaching would, in this way, act as research into discovering which traditions of a people remain when their environment changes.

Two ways of building on a regional tradition can be seen in relation to cloth-printing in Nigeria. The first uses a traditional technique but with a new personal expression, in the way that Suzanne Wenger, the Austrian artist, has treated Yoruba batik printing.[14)] The designs on her batiks are original interpretations of local religious forms. The second takes what it can from the traditional and applies a new technique to it. Imported blockprints incorporate traditional patterns and colors in new designs, which are nevertheless vigorous and suitable for machine printing. These new prints have kept alive a general dress sensibility by increasing the range and utility of cloth available, and in so doing have neither destroyed nor lowered the high level of local resist-dye printing.

Another way of building bridges to allow the strength of a folk tradition to cross and adapt to new ideas and techniques can be seen in the work done by Amancio Guedes, a Portuguese architect and painter, with relatively untrained people in Mozambique.[15)] Guedes, who has been attracted by the spontaneous ability of these people, runs an architectural practice using only people whom he has trained himself. In his backyard works a woodcarver whom Guedes found working on a building site, a bricklayer who makes murals, the painter Malangatana, servants who draw, and recently a needleworker who embroiders cloth. Guedes uses some of these people to work with him on his own projects, and the size and quality of the output not only says much for Guedes' creative and inspirational powers, but shows that such teamwork can succeed and that this studio technique can be an important educational method in Africa.

Any education in the visual arts in Africa needs to come to terms with the apparent dichotomy between the uses of traditional and new outside sources. There are some who would, either in sentimental fashion or as a nationalistic gesture, limit all artistic activity to the most literal derivation from past forms. Others, convinced that all from outside is by definition better, or at least more avant-garde, and in a great hurry to forget the "primitivism" of their past, would suggest jumping onto a completely international bandwagon.

All artists, including tribal artists, have needed to be innovators; and to try and shut out the full range of international thought is not foolish but impossible. Educational blinkers could possibly preserve narrow nationalistic thought for a short while, but it would soon die a sterile death. Those others, who would like to throw away all that has happened in the past, are trying to cut themselves off from a living source which they cannot use and the value of which they cannot see.

Creative education can hardly choose between these two attitudes, nor make superficial judgments as to which is better. Education can only provide an individual with sufficient compass and with enough self-knowledge to enable him to make whatever personal choices he feels necessary. What he wishes to include must be his decision, and this decision, so often made without conscious realization, should be based upon his own artistic integrity and sensibility, which education can only release, emphasize and direct. Education should aim at providing the basis for choice rather than making the choice itself.

It is easier to talk about goals for visual education in Africa than it is to point out instances where they have been achieved. There are at the moment few educational institutions offering tuition in the visual arts to Africans, and in southern Africa there are none.

Two summer schools held in 1961, the first in Mozambique, the second in Nigeria, although offering limited opportunity for experimentation, nevertheless provided valuable indications as to what could be done. At these schools, the exercises were brief introductions to basic visual problems. At the first school, where most of the students who attended had received previous training, the problems not only included the exploration of materials, but asked the students to produce specific images: a surreal image, for example. At the Nigerian school, the course was focused entirely on the investigation of materials from which further discovery led to broader issues. Here the exercises were arranged sequentially. The first problem was making lines on paper; succeeding problems were with paper montage, paint (first one color only), additives and collage materials (Fig. 6). The final was a three-dimensional problem.[16]

Fig. 6. Collage by Rowland Ola Abiodun, a forestry officer, Nigerian Summer School 1961.

Fig. 7. Drawing by building laborer, Mozambique Summer School 1961.

Fig. 8. Drawing by the janitor, Olu, Nigerian Summer School 1961.

Fig. 9. Walldrawings, Lourenço Marques, Mozambique.

The aim of these schools was to create for a short time an environment of complete liberation and intense work, in which young people with different backgrounds and varying amounts of previous training could find personal solutions to set problems. This could best be obtained by presenting the students with issues which they had either not encountered before, or which they had never before considered as having any visual potential. Work was consequently done with extremely cheap materials or materials not previously associated with making visual images, such as peppermints or thrown-away waste. Not only did these shock materials force students to re-examine each object and problem in a new light, but in an atmosphere of urgency and production it required them to improvise and use what was available at the moment, rather than speculate what it might have been like were they, say, at an art school in London. In areas where there is little money to spend on artist's oils, this sense of improvisation takes on a new significance.

This atmosphere had different effects on the various groups of people. The first group were not even enrolled in the course: in Nigeria the janitor of the premises, a motorcar salesman who came to sell a car but stayed to paint, a blacksmith who brought a pair of pliers; in Mozambique they were the laborers working on the still unfinished premises. They would join only after encouragement and then produce their own extraordinary versions of the problems, never failing to show up the slick solutions done by others. Here the use of non-academic materials had another advantage: instead of some being inhibited by their lack of training in formal techniques, all could join and contribute immediately.

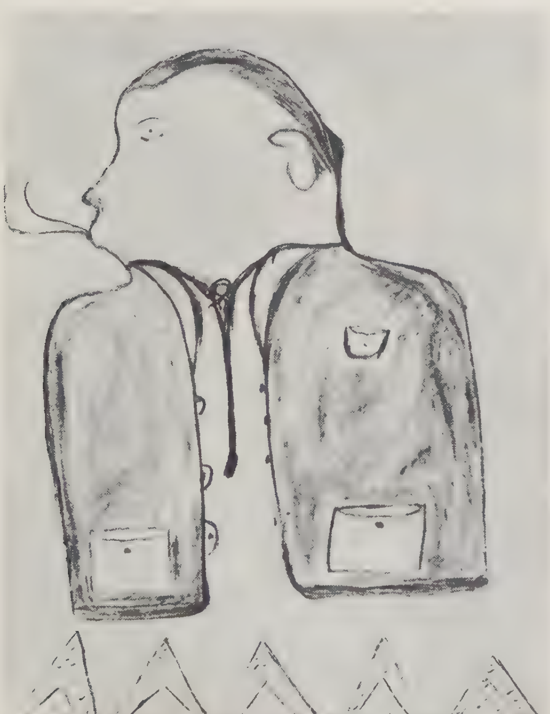
The second group were artists or art teachers, who were at first rather skeptical but would in most cases attempt things they would previously never have dreamed of doing. The last group were people who, being between the two extremes, were able to draw on and learn a great deal from both. The net result was a flow of ideas causing chain reactions of work, done with increasing enthusiasm and speed until a great many aspects of a problem had been brought to light and the walls were covered with work.

These summer schools simultaneously introduced young people to the game of creating things while imparting a sense of personal commitment, so breaking down notions of either stuffy boredom or light-hearted amusement. In an atmosphere of work freed from most preconceptions, students reproduced their own versions of many of the conventions of their folk art.

At the Mozambique summer school, one of the building laborers did a drawing of two men, one with a pipe in his mouth (Fig. 7); at the Nigerian school, the janitor drew a man with his body facing forward and a pipe projecting from his turned head (Fig. 8). On the tin walls outside Lourenço Marques, among the drawings which I have described earlier, there is one of a man in side elevation with a pipe in his mouth (Fig. 9). Besides the interesting coincidence of subject, the work of the students and the anonymous wall artist have a similar simplicity and assurance. They employ the same elementary means, the same conventions of abstracted form, to secure a direct result; yet they remain highly personal interpretations of an everyday subject.

There seem to be conventions which apply to the use of color as well. In the highly colored tribal beadwork of the Ndebele or the later paintings of Malangatana, strong color produces vibrant rhythms. At the Nigerian summer school, color was used almost invariably by the students as a flat medium, bright color for its own sake rather than for imitating anything.


7


8


9

A young girl just out of high school chose to draw birds and then paint them. The birds, ten in all, each in different attitudes of flight or rest, were formed by merely changing the outline of each form, producing images of great simplicity and control (Fig. 10). Then, in painting them, she filled in the forms with strips of strong flat color, allowing the eye to run through the whole piece along the outlines from one color to another. The background remained pure white. Here it is difficult to avoid comparison with the visual means used by the embroiderers of white pillowcases in northern Nigeria, who use abstracted form and strip color in a very similar way.

It is a fundamental premise of basic design teaching in the first years of art and architectural schools that students are forced to stop relying on the visual images which they have formed over the years in a society of low visual sensibility, and asked to replace these with a new concern for fundamental issues of form and relationship. The student starts his education "encumbered with a mass of accumulated information which he must abandon before he can achieve perception and knowledge that are really his own"[17] or "in a state of paralysis from training or observation of one idiomatic technique."[18] The catharsis and replacement is achieved by the doing of problems for which there is no direct precedent available that students may use.

The teaching dilemma occurs in the subsequent years when the student deals with issues for which there is obvious precedent--in architectural schools, the "serious" matter of designing buildings (as opposed to the "play" of the first years). Then there is a breakdown in the attempt to apply original thinking and the student falls back on the images easily available around him—a building he has seen somewhere, a masterwork from a magazine perhaps.

In the African situation, the student does not have as much which must be broken down. He comes from a society which expresses in its folk art its wide grasp of elementary visual principles. Consequently, basic design teaching seems not only to effect a quicker release, but it returns people to the visual roots of their society, and in doing so, seems likely to have a more lasting result. People then seem to revert to the firm folk base of their culture, of which they are still part and on which they can then happily innovate.

This idea is clearly expressed in a report on the Nigerian summer school: "The result of using these materials was to reveal the hidden sources of folk art in Africa. . . . The distressing fact about an urban civilisation is that the source of folk art is dammed up. It can be brought to life by stripping off the layers that have covered it up, by removing the preconceptions which they form about what art is, for example, the idea that painting or drawing is done with fine brushes and with fine paper and pencils, that they are confined to a careful imitation of the world about us, or that they are the sort of things we see kept in museums or reproduced in histories of art. Instead they will, perhaps discover the universal images that man makes of himself and the world about him. . . . It is these images which artists work on and invest with the powerful emotions that help form a national culture."[19]

This then would seem to be the opportunity that exists in Africa and similar emerging cultures: the chance to keep alive and use a living folk art as a framework within which individuals may invent personal expressions and broaden the base of this folk art with new ideas and techniques; and in so doing, they will never be left far from the main cultural stream of their own society. There is also hope in the fact that the creation of art is a natural phenomenon practiced by many people, and that teaching may be part of this process if done with a "conviction that Art is something basically natural to man; an activity motivated by faith in the actuality of existence which is outside and beyond meaning."[20]

Fig. 10. Painting of birds by Miss Yeside Soyinka, Nigerian Summer School 1961.

I have tried to indicate what are some of the important issues concerning the visual arts in the new Africa. It seems likely that much that has been described might very well apply to the general situation of emerging cultures today.

The summer school idea, besides giving valuable educational information, has in a limited way given some people direction; but enduring teaching cannot be done in the short time that these schools last, and while it is intended to continue them, permanent institutions are needed. Here not only will some of the hypotheses of this chapter be proved or disproved, but Africa will be able to discover something more of her own traditions, and in a spirit of self-discovery she will be able to produce her own artists and technicians.

There is the chance that by not destroying the fountain of intuitive ability which people still have, they will in fact be able to contribute as much to the development of their own national culture as did many of their ancestors. William Fagg expresses "the hope that Africa will make its own contribution to the world by preserving the intuitive judgment which Europe so long ago lost. It is tragic to see Africa rushing headlong into the same errors to which 'Western civilisation' fell victim at its inception 5000 years ago; in this respect, Africa could still lead us if it would read the lessons of history. Squeezed as it is between the great materialistic forces of industrial civilisation (including that of America and Russia as well as Europe) and Islam, African culture still preserves here and there in its traditional, but not in its 'contemporary' art, the intuitive vision which is virtually absent from modern art. There is still time for Africans to save it."[21)]

Just over fifty years ago the discovery of the sculpture of Africa by Vlaminck, Matisse, Derain and other European artists, had a profound effect on Western art. It is still too early to say whether a new African generation will be able to do the same. Certainly few are interested in "saving" modern art. There are too many immediate problems to be solved before the potential in Africa can be realized; but while it is early there is still the chance, and while there is such a chance there is enough room for faith and work.

1. Kwame Nkrumah, quoted in *The Times,* London (February 7, 1962).
2. William Fagg, "Observations on African Tradition", lecture given at the conference, L'Afrique et la Civilisation Contemporaine, Venice, September, 1961.
3. Ulli Beier, *Art in Nigeria 1960,* Cambridge University Press, London (1960).
4. Ben Enwonwu, "African Art in Danger", in *The Times,* London (September 29, 1960).
5. William Fagg, "The Dilemma Which Faces African Art", in *The Listener* (September 13, 1951).
6. James Johnson Sweeney, *African Folktales and Sculpture,* Pantheon Books, New York (1952).
7. Harry Norris and Hugh Seymour, "Aden Pictures", in *Antiquity* (December 1954).
8. H. T. Norris, "Tuareg Drawings on Crashed Bomber", in *Antiquity* (March 1950).
9. Ulli Beier, *op. cit.*
10. For a further description of Ndebele wallpainting, see Betty Spence and Barrie Biermann, "Mpogga", in *Architectural Review* (July 1954).
11. From a preface to an exhibition held at the Mbari, Ibadan, Nigeria, July 1961.
12. Julian Beinart, "Malangatana Goenha Valente", *Black Orpheus,* No. 10 (1962).
13. *Ibid.*
14. For a further description of Suzanne Wenger's work, see *Black Orpheus,* various issues from 1–9.
15. For a further description of Guedes' work, see Julian Beinart, "Amancio Guedes", in *Architectural Review* (April 1961).
16. For a further description of the Nigerian schools, see Julian Beinart, "Basic Design in Nigeria", in *Athene* (Summer 1963).
17. Gyorgy Kepes, *Language of Vision,* Paul Theobald, Chicago (1949).
18. Neil Welliver, "Basic Design", in *Art at Yale* (reprinted from the Yale Alumni Magazine, April 1958).
19. Dennis Duerden, "School for Painters", in *West African Review* (January 1962).
20. Alan Davie, "Notes on Teaching", in *The Developing Process,* King's College, Newcastle (1959).
21. William Fagg, "Observations on African Tradition", *op. cit.*

BARTLETT H. HAYES, JR.

ART AND EDUCATION PAST AND PRESENT

Education too often consists of the mere imparting of knowledge, whereas in its essence it is the personal assimilation of new experiences in terms of experiences already digested. A baby's first steps are tentative; only later does it dare run. In truth, the more important function of education is this very reconciliation of one fact with another, without which understanding rarely occurs. To meet a stranger is one thing. To talk with him, discover his provenance, hear his views, learn his strengths and weaknesses are successive experiences which together determine whether he remains an acquaintance or becomes a friend, or perhaps even one who is happily forgotten. Education in the visual arts has long been a stranger to the American curriculum and it may be worth looking to the past in order to learn why this is so.•

One of the salient characteristics of nineteenth-century American education was the fact that it was derived primarily from European prototypes which were designed for the aristocracy and professional people, rather than for general popular needs. The emphasis on Classics, and only latterly on science, resulted from the need to fit the minds of the few for positions of authority—preparation for law, medicine, and the management of civil and military affairs were the primary requisites. Included in the Classics, to be sure, was an occasional reference to temples and the sculpture which adorned them, but by and large the reference was slight and had little to do with aesthetic training adaptable to other needs. That, in the view of the times, was the responsibility of the home. The European cities and countryside, moreover, were lessons in the arts of the past, examples of which were to be found on every hand. Irrespective of how they may have been admired, these monuments were a significant influence. In the raw new country, however, there were no such monuments to which ready reference might be made. Consequently there was a void in the total assimilation of cultural values, except in the cases of those few who were privileged to make the Grand Tour of Europe and absorb what they could. In short, a curriculum which had been charted for the needs of European society was transplanted in the New World without providing for the difference in environment, and hence for the difference in basic need.

One may, of course, find innocent exceptions to this negative approach to the arts in nineteenth-century America. For instance, in the *Haverhill Observer* of May 27, 1803, an announcement of the establishment of Bradford Academy notes that the quarter period charge for young ladies was to be three dollars, "but for those who paint and embroider" it was fifty cents extra. But for the most part such exceptions were merely training in domestic skills and had little aesthetic importance.

There are also examples throughout the nineteenth century of Americans who discovered interests involving the arts, but found their interests abroad, having failed to find them at home: names like Samuel F. B. Morse, James Fenimore Cooper, Horatio Greenough, James Jackson Jarves, Luman Reed, James A. MacNeill Whistler, John LaFarge, John Singer Sargent, come randomly to mind among others. Their education was not the education of the academy in a strict, artistic sense, nor even of the college in respect to a substantive acquisition of knowledge; rather, it was the discovery of values which were lacking in the common American environment that led them to pursue their enthusiasms wherever they might best be indulged. But such men were few in number. Because of Morse's concern for the arts as a social force, which was evidenced by his role as a founder and first President of the National Academy of Design, he was distressed by the contrast he discovered between the status of art in the Old World and in the New. In the fall of 1811, he wrote from London: "I was astonished to find such a difference in the encouragement of art between this country and America. In

•
This paper has been adapted from an address to the Headmaster's Association, Rye, New York, February 12, 1960.

America it seemed to lie neglected, and only thought to be an employment suited to a lower class of people."[1] Twenty years later, discouraged by the continuing public neglect of art in America, Morse's active mind turned to explorations in the field of science. In short, the great majority of the American community was a people who had ignored the arts altogether for want of educational opportunities to know them and who failed to respond to something it had not experienced. The failure to respond was as natural as is the failure to respond to anything which is not heard or experienced.

With hindsight, it now seems as if the public indifference to art which so offended Morse might well have been recognized, or at least accounted for at the time. On the other hand, to *recognize* what is *unfamiliar* is a contradiction in terms. We recognize only what we have previously met. It was to take American education another hundred years or so before emerging attitudes could be documented, rediscovered, brought together and properly analyzed in order to learn from the errors of an earlier day that art must be sensed as a personal experience before it can be recognized.

If Thomas Jefferson—who most persuasively argued that an informed, intelligent people is the core of a democracy—had directed his lucid mind to the problem of discovering art forms appropriate to new circumstances, there might have been a very different history of art and art education in the decades to follow from what actually took place in America. But the prejudices of the past were too strong even for him and Neoclassicism reigned. One can only suggest that he was true to his time, and that it is only with the perspective of years that we possess insights as to what might have occurred.

We may now see that those who were entrusted with the form of education in the early years of the Republic did not notice that the concepts of art are vitally identified with the concepts of each age and that as the times change the forms of art must be reshaped. They knew that their own time and place was not a true replica of classical Greece or Rome in the realm of politics, economics or physical environment. Yet they sought to employ as symbols of their new life the images which had been begotten of the intellectual and spiritual fervor of the past. They played house with the pillars and pediments of antiquity, although they abjured the faith which those architectural elements once symbolized. They esteemed the letters and philosophy of the ancient past yet cast off its habits. They looked past the stones of a new industrial and social setting upon which a vigorous art could have been constructed and got things nicely mixed up. They lived with an inconsistency that was barely noticed even a century later, but which nonetheless exerted a depressing influence on the development of a native art.

This was a society which made it virtually impossible for true art education to exist. An extreme statement of this is to be found in a treatise called *Elements of Technology* by Jacob Bigelow, published in 1829.[2] In the introduction to this volume of essays is the following: "The imitative arts were carried in antiquity to the most signal perfection. Their sculpture has been the admiration of subsequent ages and their architecture has furnished models which we now strive to imitate, but do not pretend to excel." To imitate, but not to excel! This viewpoint—so radically opposed to the central argument of the book, which demonstrates the means to push forward in technology—sharply illuminates the misconceptions about art in that day. Education properly consists of leading from one premise to another, of building experience upon experience, yet this distinguished scientist denied that process to art education.

Horatio Greenough expressed admiration for the industrial environment which was taking shape around him: "In all structure that from its nature is purely scientific, in fortifications, in bridges, in ship-building, we have been emancipated from authority by the stern organic requirements of the works. The Modern wants spurned the traditional formula in these structures, as the modern life outgrew the literary moulds of Athens. In all these structures, character has taken the place of dilettantism. . . ."[3] But even these liberal assertions scarcely carry weight, because the style of Greenough's own work was eminently Neoclassic. Likewise Arthur Gilman, in 1844, protested the lack of progress in architecture by asking: "What could be more foolish or inept than a house like a Greek temple anyway? How could we in America expect anything but basic absurdity from an attempt to imitate ancient Greeks or medieval Frenchmen?"[4] Nevertheless, he advocated as a solution a mixture of styles which, in imitation of the social melting pot, was little more than an adaptation of many established idioms. Yet, despite such uncertainties and inconsistencies, men like James Bogardus were soon to experiment with fresh notions and the new architectural materials, iron and glass.

Although by 1850 technical changes were beginning to open the way to a new outlook on education, the common social experience of art was not sufficiently broad to readily accept this change. Art continued to exert little more than a vicarious impression on people generally and methods of art education—such as they were—remained ineffective.

Perhaps because of the increasing rapidity of change during the long span of the nineteenth century (a century is long when many changes occur and short when life follows patterns that are established and continued), there was a definite sense of progress to which each change supposedly contributed. Civilization, it was believed, was advancing; life led forward; the goal was absolute, though occasionally obscured by local events which tended all the more to reinforce the notion of an ideal toward which growth was certain though interrupted, even as the sun is seemingly brighter when exposed by billowing cloudlets than when it shines without cease. It is probably by no mere coincidence that at this time scientific learning was moving forward apace. Facts were conceived as being the foundation of knowledge; all energies were spent on ferreting them out and this inquisitional process lay within the special province of science. In sharp contrast to his belief that the arts had reached their peak in antiquity, we find Bigelow prophesying that "unless the character of the present age is greatly mistaken, the time may be anticipated as near, when a knowledge of the elements and language of the arts will be as essentially requisite to a good education as the existence of the same arts is to the present elevated condition of society".[5] Of course, one must read the word *arts* in the way that it was commonly used in that day as meaning *skill,* or *capacity* for science and technology. Bigelow makes this clear when he himself announces in another sentence, "Our arts have been the arts of science."

Indeed, the Western world was now ready for the startling revelations of Darwin, shocking though they would be to some. All eyes looked with the objective view of the camera at a world in which reality was a pocketful of facts which, when disclosed one by one, would fit together in due order. It was the business of education to exhume those facts and to train students to conform to them. And so one patiently learned arithmetic tables, drilled the rules of grammar, recited the names of rivers and capitals, committed to memory passages of approved prose or poetry in order to declaim them and supposedly absorb something of literary style, fixed historical dates firmly in mind without necessarily understanding the meaning of chronology, and apprehended scientific laws as truths not to be doubted.

In this environment, it is not surprising that art and the necessary training to produce it was regarded objectively. Certain romantic emotionalism aside, reality was found in surface appearances: in the static imitation of nature arranged precisely as observed—rock, tree, stream, cow and rainbow; in the reproduction of textures—the gloss of hair, the sheen of silk, the glint of glassware; in the accurate transcription of color relations as they were literally observed—the red of the apple which possessed no poetic reference to Eden, but rather the prosaic quality of the skin of a particular fruit. And so the art student monotonously copied plaster reproductions of Classical statuary, laboriously constructed artificial shadows induced by the colorless material, faithfully studied rules of a fixed perspective and imitatingly pressed clay into an inert lump. Meanwhile, the patron took pleasure in having recalled for him those things which he already knew; in his view, painting and sculpture were documents to preserve the familiar; they were reminders that reality was tangible and might be possessed; they were, indeed, stabilizing factors in the midst of day-by-day uncertainties, instilling confidence in a natural world which the artist had found good. And, as one looks casually out the window, so one looked occasionally at the painting on the parlor wall.

Although this image of nineteenth-century art, society and education may not be entirely just, I believe it is sufficiently accurate to provide a helpful contrast with today. For one thing, those changes which then seemed so rapid now seem more leisurely when compared with the extraordinary speed of events in recent years. Accordingly, it has become necessary to make new adjustments to fresh circumstances. Gone is the sense of the absolute. Destiny is no longer a shining star, for we have learned too much about the physical composition of celestial bodies to let any one of them serve as a specific symbol. To look forward is no longer enough and so we have now accustomed ourselves to looking sideways, backward, upward, even inward. For I doubt if there is a people in history who has found itself so conscious of its identity in the passage of time, who has weighed so delicately the relative situations which constitute its existence, as do we in mid-twentieth century. To perceive what is relative has, indeed, replaced what merely fitted into a sequential scheme of things. Today 2 is more important as a quantity in relation to 1 and 3 than as a succession 1, 2, 3. Today one is more inclined to ask, "What kind of a road is it?" than, "How long a road is it?" or, "What is the novelist or playwright driving at?" instead of, "What happens next?" or to want to know, "What is the meaning of a picture?" rather than, "Is it skillfully painted?"

We have been led into this new way of thinking not only because we have had to adjust to constantly altering circumstances wherein there is no established core, wherein all is fluid, but also because of the narrow specialties into which the sum of our knowledge has been divided. So isolated has each specialty become that one professional can scarcely talk to another and everyone has become a layman except in his small area. Some connection between these divisions is now needed for the very sake of society itself.

On the other hand, the seeming insecurity of today might imply that we suffer for want of absolute ideals (certain political groups support this view) and that grandson would be much better off if he returned to the good enough ways of grandfather. "How am I able to know what the painting is all about if the artist doesn't make himself clear?" This is the oft-heard complaint about modern art. The question is not asked amiss because adequate education for all citizens is not yet available to provide the answer. It presumes, innocently enough, that the artist must speak to all alike, whereas, in fact, all cannot understand him any more than all can equally understand the physicist or mathematician. Thus the arts, like the sciences, can mean different things to different people.

Nevertheless, despite the variety of meaning, we can by our will to survive construct an image which will support us in the midst of a multitude of uncertainties. This image is analogous to the way that learning served the wants of earlier societies. Art is now therefore discovered to be an instrument for persuading society to accept the unfamiliar along with the familiar, to tolerate the stranger rather than berate him, to sift random bits of evidence as well as "traditional" ways, to be as discerning of the wine as of the label, to believe that all is neither evil nor good.

An art so conceived parallels new concepts in other areas of inquiry wherein dogma has been replaced by an open mind ready to scrutinize issues and come to conclusions which are based on broad appraisals. This is not to reject the inherited knowledge, but to take new account of it, revalue it and apply the findings in tentative terms to whatever situation warrants the application. The lore of the alchemists has been revised for more practical ends; "witches" are now cared for in hospitals; tribal fetishes have provided new insights as to the nature of art. The viewpoint has altered from Bigelow's confession of inadequacy, in the realm of aesthetics, and has become identified with that same spirit of inquiry and invention which he admired in science. Consequently, learning by rote has yielded to the teaching of experience whereby each fresh adventure is compared to others. Indeed, it seems that intuitive concepts which grow from experience are inevitably accompanied by subconscious comparisons, else they could never occur.

Thus, to summarize, whereas nineteenth-century art served to remind one of what he already knew, the art of today is a medium of discovery, the most obvious testimony to which is the frequent complaint of the public that it does not understand. Just as the documentary nature of art corresponded to the objectivity with which knowledge was sought a century ago, so the imaginative revelations of modern art accompany the modern mind, which probes subjectively into the innumerable relations of things. The shepherd at sunset, the ship at sea, the soldier on the march, the not-so-divine goddess by the brook represented recognizable experiences, even if credulity had to be slightly stretched on occasion. Paradoxically, this earlier painting seemed real but was an illusion, whereas abstract art of today, being unfamiliar, seems unreal. The latter painting owes its aesthetic interest to the actuality of the painted surface. The painted illusion of the nineteenth century was finite; the modern painting is infinite, as infinite as a mathematical formula which serves a countless variety of specific instances. The earlier painting told one story, the modern one tells many. The meaning of a painting which illustrated a particular aspect of nature—a nature well known, well understood—was specific. There was no question as to the identity of what was represented. The meaning of a modern painting is avowedly imprecise, ambiguous, indefinite. Like music, the art of mid-twentieth century—painting, sculpture, photography and the several crafts—can evoke many associative ideas, depending on who observes it and on his mood at the time. The very message of modern art is emotional and relative; contemplating it, the observer can develop his own concepts—concepts which the artist himself may never have conceived. Is the artist to say what his painting shall mean? Is the carpenter to say how the house will be used?

The artist is variously author, editor and reporter of the many ideas which mold our present environment, and his training requires new and appropriate ways of seeing and working. This does not mean that the discipline of eye and hand are no longer needed; on the contrary, they are, if anything, more needed than before. It is one thing to copy the natural appearance of an object whose constant presence is a guide and the order of which is established in advance. It is quite another thing to control an image which is not yet consciously envisaged. Modern art emerges from the very process of its creation. It does not exist until it is complete. The pudding may not be proved until withdrawn from the oven. Ideas and feelings concerning art alter during its evolution and the art changes with them. Meticulous skill and much experience are necessary to bring order from the flux of possibilities that precede its ultimate formation. The apparently effortless execution is, in fact, testimony to the dexterity of the artist who is able to conceal the effort.

The real problem of education is that we teach by what we have learned in the past, but that we do so in the present for the benefit of students who must live in the future. The teacher is most effective in a civilization wherein sociological changes are slow. In one wherein they are rapid, he is, perforce, less effective. Nevertheless, we cannot hope to stabilize the modern environment by perpetuating old values and ways of evaluating, but must reappraise our educational disciplines and emphases.

Art may contribute importantly to the development of the whole being. Now added to the acquisition of technical skill is the need for conceptual skills which will serve to manipulate the nascent image. When formerly the image of the apple was reproduced, it could be painstakingly studied and the more accurately it was represented (in the photographic sense), the less mental effort was required to appreciate it. Observation alone sufficed. But the more abstract the rendering becomes, the more need there is to draw upon other intellectual processes: analysis and synthesis, perception, intuition, invention. As a consequence, the training of such faculties becomes basic for art today, and by providing such training art becomes basic to the system of all education.

And so the form of education changes from its erstwhile emphasis on committing isolated data to memory, to a form which is flexibly adjustable to relative situations, to one where the development of insights is as vital an element of training as the opportunity for expressing them. For, to become involved with the processes of painting and sculpture without considering the concepts which both influence and result from them, is as one-sided as assimilating historical information about art without the actual experience of it. Through both experiences—conceptual and expressive—art reconciles the intellect with emotion and thereby contributes to scholarly poise in an important way. The chalice is not alone for drinking. In keeping with the modern dependence on judgments which are conditional, art is not involved with decisions as to right or wrong. It is concerned with what is appropriate or inappropriate, satisfactory or unsatisfactory, with structures which are always tentative and are often altered by nonrational causes. Art can naturally accustom the student to come to grips with what is fleeting and to acquire a sense of security in doing so. He thereby develops resourcefulness in adjusting himself to the unexpected, which can habituate him to facing the sudden complexities of modern life with confidence and to performing in an individual fashion with assurance and responsibility as democracy demands. Art provides him with the opportunity to become his own teacher by creatively exploring areas which no one has yet learned; indeed it is a convenient laboratory for this purpose. It supplies him with disciplined vision which accompanies him every waking moment and is but remotely related to the formality of the ordinary classroom. Art encourages the student to discriminate visually and intelligently and so to develop a valid taste of his own. Art is his personal embrace with education.

1. Morse, S. F. B., *His Letters and Journals,* edited by Edward Lind Morse, Houghton Mifflin Co., Boston (1914), p. 46.
2. Bigelow, Jacob, *Elements of Technology,* Hilliard, Gray, Little and Wilkins, Boston (1829).
3. *A Memorial to Horatio Greenough,* selected writings edited by H. T. Tuckerman, G. P. Putnam, New York (1853), Essay on Structure and Organization.
4. *North American Review,* 1844. Quoted by Talbot Hamlin in *Greek Revival Architecture in America,* Oxford University Press, New York (1944).
5. Bigelow, Jacob, *op. cit.*

ROBERT PREUSSER

VISUAL EDUCATION FOR SCIENCE AND ENGINEERING STUDENTS•

Education today is faced with the overwhelming task of serving as a clearing house for vast bodies of new knowledge and is absorbed with the need for preparing students to apply that knowledge to every aspect of our changing environment. The concept of teaching "a little about a lot" has disappeared, but specialization within a single discipline is also becoming outmoded. Knowledge has expanded in every category of learning so that both objectives are impractical and impossible. We have only to observe the rapid changes occurring in all phases of science and technology to realize that training in current techniques and procedures does not necessarily assure competence in those of tomorrow. Curricular revisions are being made with the aim of creating a broad base of knowledge which will later serve the student as a solid foundation from which he will be able to work as changes occur in his profession. In mathematics and the physical sciences, short-lived techniques and vocationally-directed learning are giving way to an integrated study of fundamental and basic knowledge.

With this trend toward integrated learning, the education of vision takes on importance in scientific and technological training. There is increasing support for the theory that perception and formation of visual order can prototype response to, and structuring of, order on all levels. Explicit in scientific learning is the preoccupation with identifying and measuring which tends to anesthetize the capacity to see directly without the aid of instruments. Study of design enables the student to achieve visual coherency, and trains his eye to perceive relationships of parts to the whole.

Visual training, although used as a primary tool in aiding the child's discovery of the world and his efforts to orient himself within that world, is severed from the learning process as adolescence approaches. In other studies, such as mathematics or linguistic composition, the subject's increase in complexity is commensurate with the maturing of the individual. Visual education unfortunately follows no such logical development. Yet scientific curiosity leading to discovery and invention needs the stimulus of visual as well as mental contemplation. Both the scientist and the artist are motivated by seen and unseen structural orders, and are dedicated to unraveling their mysteries. They seek the same principles of unity and organization, though in different ways and for different purposes. The functions that both perform of perceiving rhythm, pattern, proportion and form are parallel and analogous. Often defying verbal classification, phenomena and functions in the world of science and mathematics depend upon visual translation. Through the re-education of the eye and the reanimation of the sense of sight through creation of visual form, the dimensions of scientific thought are extended.

Luminaries in science and mathematics affirm their reliance on instinctive reasoning, and consider that intuitive awareness is as essential to invention and discovery as are the inductive analytical procedures. Scientific training, however, concerns itself with quantitative, rational, and objective thinking, often leaving untapped the intuitive and subjective powers of the scientific or technological student. There is need for the stimulation and strengthening of these powers as the student gains technical knowledge and proficiency.

Keeping pace with the physical sciences as they change our view of the external world, behavioral sciences are unraveling the complex mechanism of the human mind. Psychographic studies of healthy, productive minds are expanding the accumulation of knowledge gained in the diagnosis of mental disorders. Such psychological probings have made it clear that the region beneath conscious and rational levels of thought need not be a repository for repressions but can be a wellspring of expression.

No master key fits all complexities of creative achievement, but education can take advantage of those disciplines which are rooted in and focused upon intuitive insight. Among the arts there is no more fertile ground for research in the phenomenon of the human psyche (as it applies to thought, feeling and action) than procedure and achievement in the visual arts. The alliance of intuition and intellect, as observed in visual expression, provides an insight into the nature of creativity. A successful painting undergoes many stages of intuitive and intellectual change, becoming, in its final form, a dynamic visual composite of balanced interactions between conscious intent and subconscious will. When the non-artist of specialized training is involved in this procedure, he experiences a pattern for creativity.

• All the works illustrated in this paper were executed by students of the author in his visual design course for students of science and engineering at the Massachusetts Institute of Technology, Cambridge, Massachusetts.

The discipline of visual invention, organization and expression, focused upon subjective-qualitative values, serves as a counterbalance to inductive-quantitative learning on which scientific education is based in its formative years. It demands a shift from reliance upon the outer world of fact to the inner world of feeling and leads to a greater dependence upon the in-dwelling powers from which creativity springs. Unlike science, in which a working knowledge of its fundamentals and methods of verification precedes invention and discovery, the practice of art permits creative application of its principles while learning about them.

Although students of science and engineering have no less creative potential than those attracted to other disciplines, the nature of their training makes surrender to the creative process in art more difficult. Since it is a field outside the immediate requirements of their specialization, and one that refuses to be bound by quantitative standards, little hope is held that it can be fully comprehended or formularized. Misconceptions about "talent", "skill", and "ability to draw", as prerequisites to participation in art, form a barrier for non-artists to the fruitful experience that could be theirs. Many are unaware that they can effectively participate in visual design regardless of their specialization, and that such activity can be an integrating force in their lives.

Studio procedures that will attract the scientifically trained student require a departure from the vocational approach to art. Thinking, seeing and performing must be divorced from professional goals in the fine and applied arts. For the art experience to be of lasting value to the scientific or technological specialist, practice must be directed in such a way as to contribute to a view beyond the boundaries of his specialization, as well as to effect a release of his creative potential within the context of his profession. These objectives demand revised teaching methods, designed to invite participation without resorting to conventional forms of drawing, painting and sculpture.

The student who has attained a working knowledge of the slide rule, pressure gauge, or electronic computer is inclined to shy away from charcoal, brush or chisel, which symbolize competence and talent in an alien profession. Thus, the goal of the studio experience is not emulation of the artist's product, but comprehension of the artist's thought process in developing capacity to plan, organize, clarify and integrate in visual terms.

It is necessary not only to direct studio activity so that it may prove meaningful to students who have had no previous art experience (and do not intend to become artists), but also to design a course that can challenge the scientifically minded. Personal feeling and judgment, often submerged beneath patterns of conformity, must be released by overcoming self-imposed limitations and acquired visual clichés. This is achieved by exercises which break through conventional patterns of thought rather than stringently disciplined ones which reinforce inhibitions. Textbooks and formulas are of no avail when the student stands on the brink of this adventure.

Courage to observe, explore and experiment is engendered by a sense of accomplishment based on discovery. There should exist in the initial problem, as well as in those to follow, the potential of achieving something beyond the assigned task. In the beginning, the surprise of discovery is more important than concentration upon predetermined content.

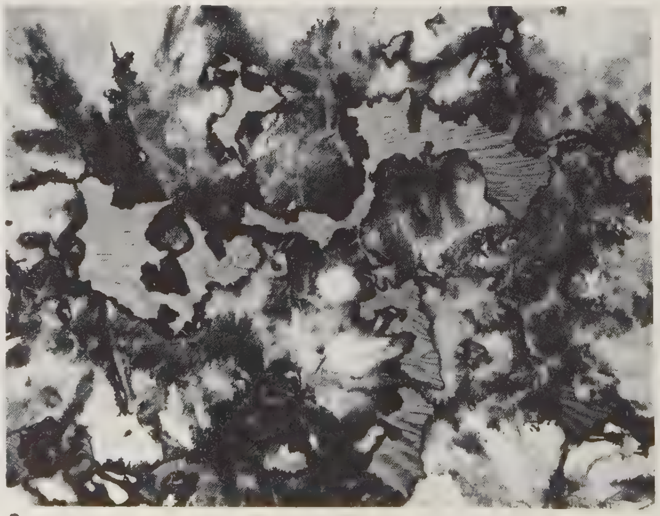
There is much to be learned from the phenomenon, "beginner's luck". All have had such experiences in varying degrees and have witnessed them in others. When this occurs, it is as much a surprise to the participant as it is to the observer. The person who wins the first time at cards, hits a home run the first time at bat, or correctly answers a question in an area with which he is unfamiliar, usually refers to his achievement as a "happy accident". Frequently, such success can be traced to intuitive response in the form of physical or mental spontaneity, indicating that the unconscious is a reservoir of instinctive knowledge. Uninhibited by established rules and skills, the uninitiated perform without fear or timidity. Such incidents, in the initial stage of creating visual form, generate enthusiasm and heighten involvement. An unconscious desire to create may be revealed to the student through such activity.

Discovery and development of unexpected configurations become a manifestation of personality. It is a form of visual play which perhaps had its origin in primitive man when he observed chance formations in nature and capitalized upon them by shaping a vague form found in a clump of earth or scratching an image suggested by shadow play on a cave wall. Many centuries later, Leonardo da Vinci, intrigued with the images he could discover in natural phenomena such as in cloud formations and veiny marble, exercised this form of visual imagination. In the development of modern art we find evidence of the accidental being exploited. The Cubists did so by making collages from pieces of paper, bits of wood and scraps of other material collected at random. The Dadaists carried this idea a step further by tearing rather than cutting paper and letting its arrangement result from the "law of chance", thereby freeing shape configurations and their placement from premeditated control. Much of current painting and sculpture is a product of the artist's effort to make it possible for the accident to happen and to capitalize on it when it does. The history of scientific progress is not without parallel in this regard. Chance observations have been instrumental in forming concepts and unpredictable experiments have led to discoveries.

Imagination and resourcefulness in capitalizing on the accidental in search of visual form is demonstrated by floating color on glass and imprinting it on paper with frictional pressure (Fig. 1), or mounting a randomly charred and burned sheet of paper on contrasting rhythms of a plywood panel (Fig. 2). Involvement in this process, which is vital to art and science, authenticates the unpremeditated and intuitive phases of conceptual thinking. Observing and developing chance formations in nature, or creating situations in which visual discoveries can be made, also increases perceptiveness and inventiveness in future scientists and technologists. No matter how disciplined the formal aspects of subsequent exercises become, it is essential to build on the confidence gained from this experience, which confirms the fact that professional artistic skills are unnecessary to reclaim innate creative ability.

The key to maturity of visual expression is a sequence of tasks, from the extreme of subjective spontaneity to that of objective concentration upon specific visual considerations. A directed use of the subconscious is helpful in building a bridge between the two. The universal desire in man to leave visible evidence of his presence is manifested by the lines his fingers scrawl on a sandy beach and the doodles he pencils in a telephone booth. This urge to scribble is the only remnant of childhood graphic expression evident in the adult. It is the handwriting of the subconscious, a spontaneous act connecting with the past, when discovery of this kinesthetic pleasure became the child's first means of visual expression. This form of subconscious play may be employed in the transition from intuitive process to controlled manipulation of the visual elements.

1



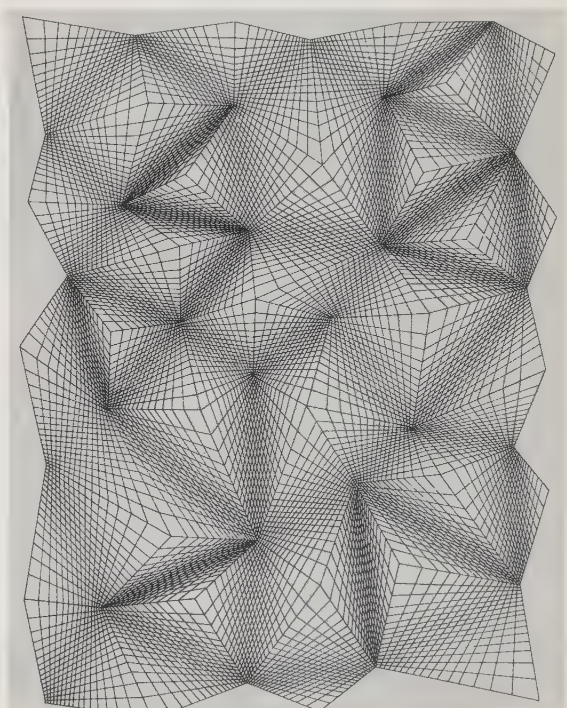
2

If asked to cover a surface with lines, each student automatically resorts to his own style of doodling. No two efforts are alike and each performs with originality. Establishing personal identity with his first effort, the student is motivated to consciously use the distinctive patterns of his subconsciously developed style. By encouraging unconventional media, such as the substitution of string for pencil, he practices intimate coordination of eye, mind and hand (Fig. 3). Fig. 4 illustrates how a mathematically inclined student succeeds in the more specific task of creating an illusion of undulation with line. He intellectually applied the subconscious process of which he was made aware in the preceding exercise. The use of line to enhance or transform surface by conventional or unconventional methods emphasizes presentation rather than representation.

The following ideas present a logical sequence and are intended, like the previous exercises discussed, to suggest only one of many avenues that should be explored with each stage of the student's development. When formulating more deliberate, rational and systematic problems, it should be remembered that the child progresses from preoccupation with line to color manipulation and shape invention. For the adult, concern with these elements can be a connecting link with the art experience where it terminated in adolescence. Study of color, then shape, independently and as they relate one to the other, constitutes a vital continuum in the learning process as the student regains command of the visual elements.

The most elusive element is that of color. Because of its emotional appeal and psychological overtones, it is an element to which the individual automatically responds. However, a manipulative study of color is required to extend the visual language. Though initial response is subjective, color can be made of absorbing interest to the analytical mind. Practicing control of hue, value, and intensity is basic to this interest. It gives the student a vocabulary with which to work as he investigates the psychological and physiological ramifications of color. Study of these phenomena need not be limited to the application of paint with brush. No less valid, and frequently preferred by the non-artist, is the substitution of colored paper for paint. The projection of colored light is another alternative to painting with light. Dynamic aspects of color such as spatial dimension and simultaneous-contrast effect, visually measurable

3

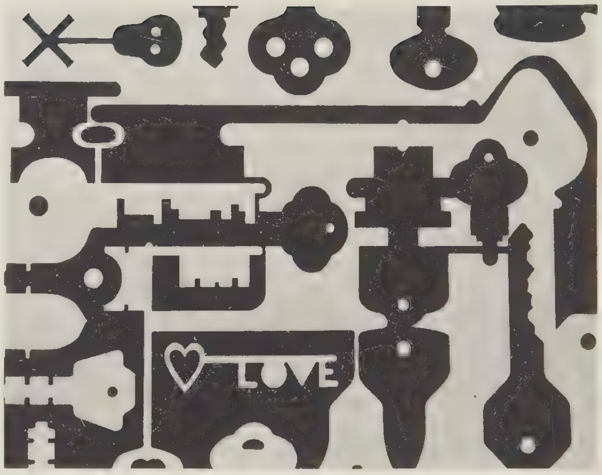


4

weight and temperature, constitute prime areas for research. Manipulating these phenomena originates a variety of experiments in analyzing and confirming theory, and anticipates their application to future projects. Beyond this it has significance for non-artist and artist alike, as it reveals the nature of perceptual orientation through visual experience. In the analysis of simultaneous contrast, the discovery that the appearance of identical colors is modified when seen against different colored backgrounds dramatically demonstrates that how and what the eye perceives is contingent upon the coexistence of figure and ground. This phenomenon has relevance within the context of human perception in that it proves response to fact is conditioned by the environment in which it exists.

Inasmuch as shape, no less than color, is inseparable from background, concern with their interrelationship is fundamental to the study of the element of shape. One means of focusing attention on this conditioning factor, when inventing and designing shape, is to require shape and the space containing it to be interchangeable. Figure-ground reversal poses an intriguing problem, demanding ingenious juxtaposition of an image against its reversible background, and causing the spectator to actively participate by resolving the tension between positive and negative (Fig. 5). The task of stylizing an image so as to achieve this form of visual ambiguity appeals to the logical mind.

Inventive manipulation of each element and analysis of their unique characteristics prepare the student for assignments in which two or more elements are combined. This stage of studio practice introduces basic design principles including such organizational factors as grouping, contrast, similarity, pattern, rhythm and continuity. In Fig. 6 textural contrast is used to emphasize shape refinement of the plaster relief. Perceptual sensitivity with the capacity to make subtle adjustments of contour respecting positive and negative components (as practiced in the figure-ground reversal problem) is realized in this study of complementary elements. An



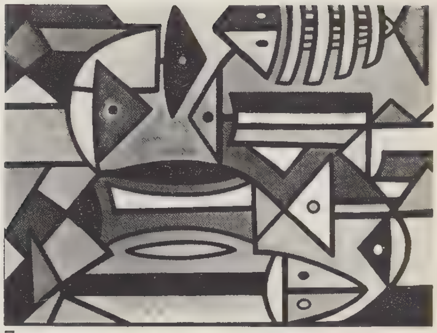
5


6

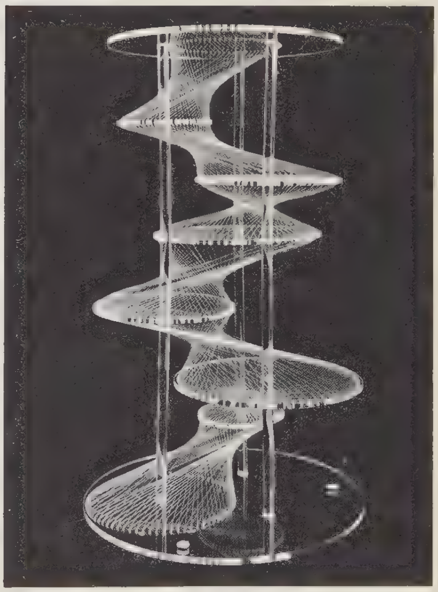
exercise in variation on a theme incorporates color, shape and line in applying the principles of design (Fig. 7). Despite the restriction to a single theme, variation in shape, size, position, direction, and color acknowledges the eye's search for variety, in fact its demand for it, if visual attention is to be attracted and maintained. This preoccupation with organizing the visual elements trains the student to perceive and structure order. Command of the visual language extends the faculties of seeing and thinking in terms of relationships, and thus enhances professional performance and enriches human experience.

As confidence mounts with each succeeding exercise, intellect, intuition and purpose become one. Engaged in the artist's visual-thought process without the barrier of competitive professional considerations, the student is responsive to art as a disciplined process demanding respect for its elements and the principles of their organization. Independent action framed in the vocabulary of visual design is thereby motivated. Initiative and self-reliance should be encouraged in the formulation, execution, and critical contemplation of completed works. Each student's visual curiosity is best nurtured by focusing upon general and specific considerations as they apply to the task at hand, at which time the student is most receptive.

When projects are independently formulated, procedures and results vary in accordance with the individual. Sometimes surprisingly refined concepts and techniques materialize, as in the construction made of plastic and nylon cord seen in Fig. 8. The ability to conceive, plan and execute a complex three-dimensional form utilizing engineering skill is apparent here. Lack of such skill and manual dexterity, however, does not prevent another student from exercising his creative powers. The rhythmically textured seed mosaic (Fig. 9) created by a student of mathematics, though on a different level of visual curiosity, is no less inventive. Both efforts were based on the students' own ideas and resourcefulness, which required intuitive and intellectual self-discipline.



7



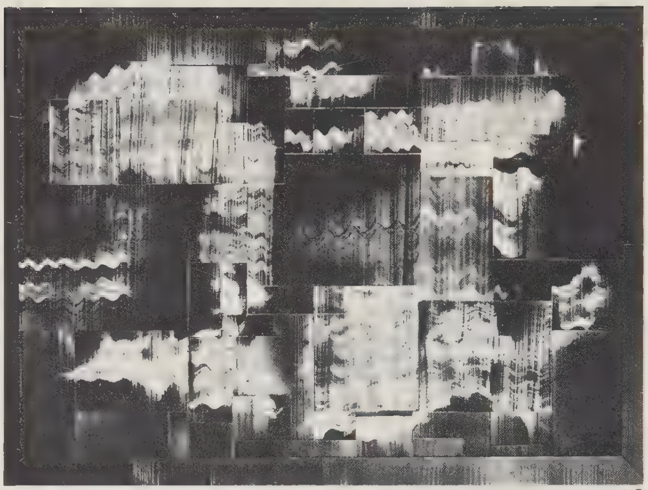
8

9

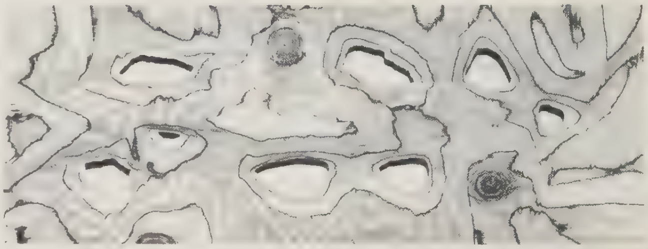
Though there are guideposts along the devious passageway of creativity, they are not systematically mapped. In this labyrinth, concepts do not necessarily precede discoveries and, in fact, often preclude them. Visual invention can depend as much on media and process as on preconceived ideas and premeditated images. Fig. 10 shows that the method of applying a medium can be instrumental in evolving a design. Ink was scraped across a sheet of paper in a series of wavy motions, using a cardboard edge. The undulating rhythms were then cut out and reassembled in an ordered arrangement of light and dark intervals. At no time is the importance of avoiding preclusions more saliently evident than when the interaction between materials, tools, and techniques is explored as a source of inspiration. Fig. 11 resulted from experimentation with a sanding machine, cutting through layers of laminated plywood. Respect for this interaction, permitting it to suggest and effect form, can produce expressions of experience no less valid than those achieved by the predetermined method.

The use of tools to make visible inherent rhythm, pattern, texture, and color does not negate control of form. Knowledge gained from analysis of organizational principles may be effectively applied to design guided by this procedure. When the mind and eye have been conditioned to these organizational principles, unique characteristics of materials and technically appropriate tools can suggest procedure and permit controlled manipulation and arrangement of intrinsic structural orders. This occurs in the conscious alignment of patterns and textures made evident in selected wood units cut cross-grain (Fig. 12).

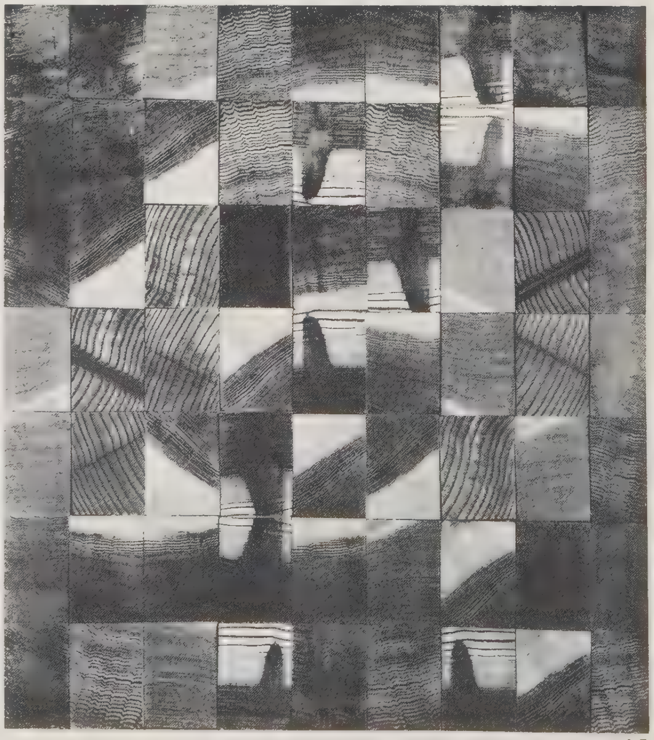
The yielding of material to manual process, as yet another means of creating form, is apparent in the three-dimensional paper elements seen in Fig. 13. Tensions obtained by joining the edges of slits cut in scored, free-form paper shapes was the technique devised to transform the two-dimensional material into sculptural units. In a well-equipped studio workshop, machine tooling offers still other modes of transforming various materials. Circular and band saws, lathe, milling machine and drill press are but a few of the tools which give procedural clues to the visually oriented mechanical engineer. The machine-formed relief arrangement of three-dimensional sections cut from a single piece of wood, seen in Fig. 14, required manual-visual coordination in the yielding of material to machine process.



10

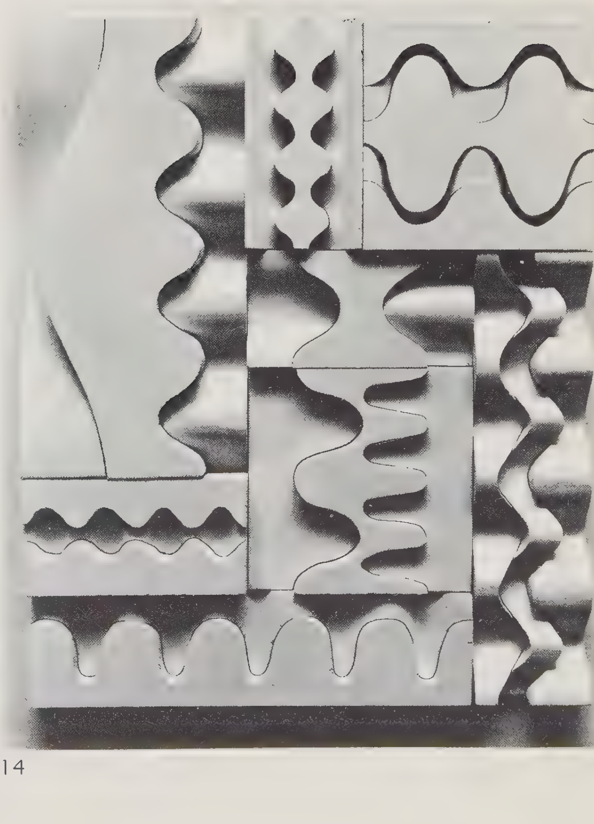


11



12

13



14

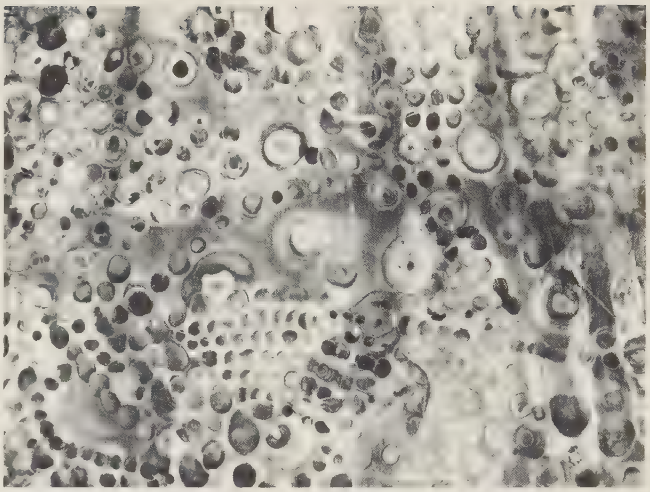
When specialists explore the aesthetic potentialities of materials with which they are familiar, unsuspected visual qualities are discovered. A student of metallurgy observes that his blow torch can suggest a motif and release a rich color orchestration when its flame is applied to a sheet of copper (Fig. 15). Control of temperature and distance between blowtorch flame and copper surface makes possible the variations in color and size of motif. Another future metallurgist, intrigued with the beaded-linear quality of molten lead solder, finds textural possibilities for enriching the surface of a sheet of tin (Fig. 16).

Whereas the applied sciences suggest the use of industrial materials, tools, and techniques as legitimate means of practicing visual design, the natural sciences and mathematics can suggest application of physical processes, natural forces, mathematical ideas, and scientific instruments.

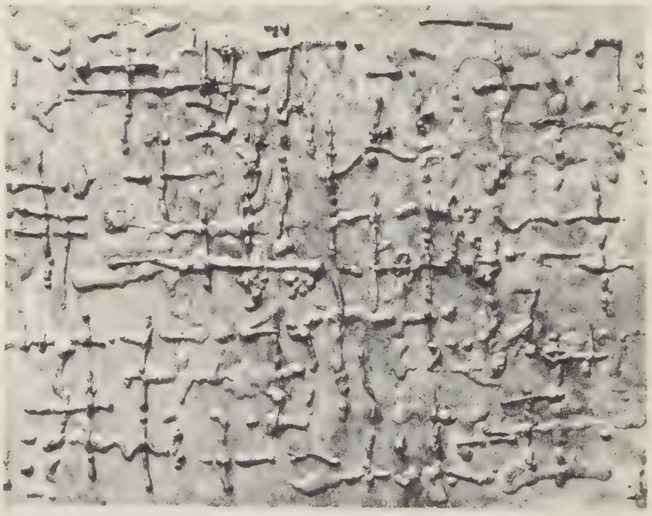
Chemical processes often display captivating visual effects. In his laboratory, the chemist cannot but witness the visual elegance of his world and be moved by it. Knowledge in this field makes possible exploitation of chemical transformation for visual effects. In Fig. 17 a pictorial fantasy has been created by covering glass with gelatin emulsion made from photographic film dissolved in acetone, and controlling its drying time through heating and cooling.

The design-conscious student of physics may employ natural forces to heighten visual interest. Familiar with magnetic force, and having access to equipment for magnetizing metal, he creates variety in uniformity by introducing motion in a uniform grid arrangement of modular units mounted with pins (Fig. 18). A motorized magnet on the back of his panel sets the orderly array of magnetized triangles into slowly rotating, ever changing directional relationships. The north-south pole orientation of the metal units causes their interaction as they are activated by the rotating magnet concealed behind the mobile-relief.

Aware that inherent in mathematics is the potential of aesthetic experience, the student of this discipline may use its formal logic to determine relationships and proportions in the structuring of visual order. In Fig. 19 he has instinctively utilized this logic when organizing the diagonally divided squares which were calculated so that no two are of equal dimension. Execution of the design in levels of relief makes possible the emphasis of squares or triangles and change of rhythm through control of a light source.

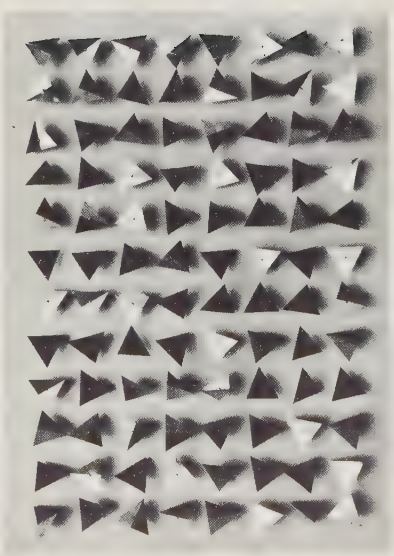


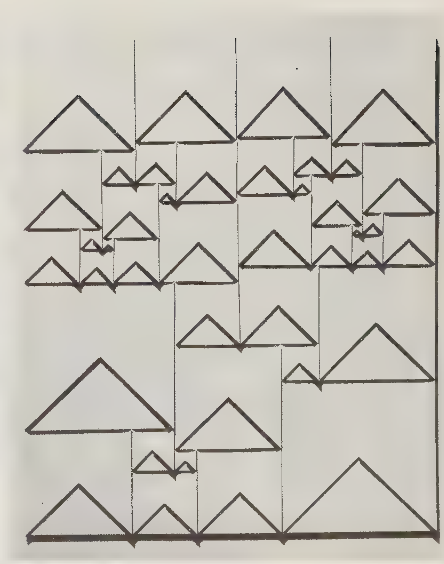
15



16


17

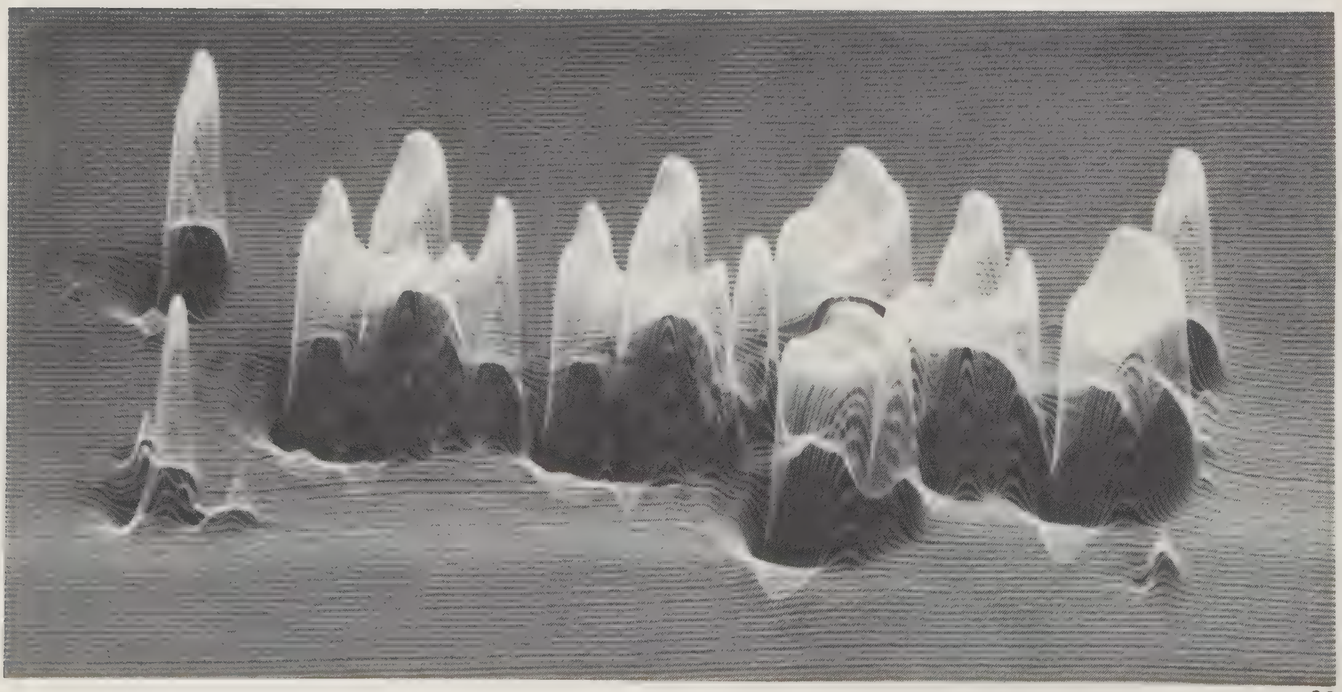

18


19

The scientific mind trained in imaginative visual thinking is especially suited to experiment with data-processing equipment. The use of the electronic computer as a visual design tool dramatizes how instruments of science and engineering may be related to visual study. Though its versatility is well known, the potentialities of its application to visual research have scarcely been tapped.

Random variables in conjunction with mathematical functions (when placed on magnetic tape and fed to the computer) generate linear patterns. Also, images from the outside world may be transformed through control of their input by converting parameters of dimension, color, or luminosity into different domains and programming them for display on a high resolution oscilloscope. Intensity domains are produced when a single source of illumination penetrates holes in a black plate. The phenomenon of light is utilized as an element of design under controlled and programmed conditions. This transformation is achieved by feeding the image directly from TV camera to computer and controlling the computer's representation of the data on an oscilloscope (Fig. 20).

Among the many ways of implementing computer process design that have yet to be explored is the recording of information received by camera on magnetic tape, and substituting the oscilloscope with a tape-controlled milling machine as an output device. This procedure anticipates exciting visual rewards in the translation of two-dimensional surface into three-dimensional form, or in reforming three-dimensional volume by varying its illumination.



20

From inception to completion, visual invention and organization are a series of decisive actions determined by instinctive and acquired knowledge. Students of scientific-technical temperament are attracted to visual experimentation upon finding that media, tools and techniques, with which they have a working knowledge, may be used in the creation of visual form. Each of the disciplines fundamental to science and technology offer aesthetic vistas to be explored. Originating explorations of this nature, and directing them as they unfold, frequently has more meaning for these students than employing paint, brush, and canvas.

Such innovations, departing from traditional studio practice, permit teaching the principles of art without requiring mastery of the artist's media. Recognizing that profound expression in art is a rare human achievement that cannot be taught, the instructor does not attempt to make artists out of everyone. Rather, he promotes the artist's creative process as an educational means of expanding and deepening the dimension of human performance. Though this objective implies that the visual forms created are important only in that they develop the student's reliance upon his inner resources when approaching the imaginative challenges of his particular profession, it is worth noting that there is an interesting by-product. Sensitized to visual values and order, the student of science or engineering exercises unsuspected flexibility and ingenuity which professional art students might well emulate. Innovations occur which, if employed by the artist-designer, could enrich the visual world. The scientific-visual experimentalist discovers that ways and means, originally developed for functional purposes and as solutions to practical problems, often have aesthetic potentialities unfamiliar to the artist. Not only are new textures, patterns, rhythms, colors, and forms made available for extension of the artist's media, but dispelled is the notion that science is incompatible with art. This newfound kinship augurs well for an alliance between art and science as it becomes evident that the developments in both affect the substance of each.

Vainly seeking order in an environment of encroaching chaos, the eyes of the average man have become immune to ugliness. Unconsciously he builds up psychological and physiological defenses. Desensitized by this process, man depends less and less upon the sense of sight to criticize constructively and respond visually to the world about him. The structuring of the man-made world is increasingly dependent on aesthetic discrimination in selection, rejection, analysis, arrangement and manipulation of form. Alerted to problems of achieving visual order, and sensitized to visual values, students of science and engineering will be in a position to complement the efforts of architects, city planners, and industrial designers. By active concern or by creative engagement, the services and products of their specializations will be related to a larger complex. An understanding of responsibility beyond professional borderlines contributes to improvement of the total visual environment. This is an extra dividend from learning the visual language by participation.

Of significant value in this educational investment is the influence it exerts on personality by contributing to the maturity of the individual. This maturation depends as much on a search for personal identity as on establishing professional identity. The creative nature of visual expression, the fostering of originality, promotes self-realization by its insight into nontechnical values, and develops critical inner standards. The expression of thought, attitude, and feeling in visual terms complements involvement with the impersonal language of measured quantities, operational symbols, and functional performance. At the same time it cultivates spontaneous responses and sharpens visual perception, both of which are essential to individual fulfillment and professional attainment.

Visual education with these objectives transcends the vocational approach to art. It develops in scientific and technological specialists the power of visualization (which is as basic to human performance as verbalization) and aids in overcoming the delimitating nature of modern education with its dichotomy of thinking and feeling. Students receiving this training display, in the forms they create, the collaborative function of intuition and intellect. This gives cause for optimistic speculation. We may hopefully predict an educational reality wherein visual and verbal literacy as well as intuition and intellect are synthesized.

ROBERT JAY WOLFF

VISUAL INTELLIGENCE IN GENERAL EDUCATION •

It must be remembered that no work is required to be more than right as far as it goes; the greatest cannot get beyond this and the least comes strangely near the greatest if this can be said of it.
(Samuel Butler)

There are obvious dangers in any attempt to give a unique, contemporaneous particularity to certain widely observed "oddities" in the current human condition. For example the absence of initiative, originality and independence in adolescents and young adults has finally evolved into an image of an inert generation. The evidence for this generalization, while abundant, is fragmented and misleading.

Any college student with the gift of swift verbal comprehension, a retentive memory and a strong concern for personal status, may statistically earn the title of "superior". Yet, insofar as the quantitative scope of his achievement may cover the absence of qualitative depth, to call him superior could indeed be less than the whole truth. When this swift young mind is held back by the slower pace of his "average" classmates, a new half-truth appears in the form of a specifically accelerated study program for his benefit. The hope here is that superiority, vastly accelerated, will lead to higher and more advanced levels of superiority. But what is often accelerated is not superiority of mind and spirit but rather tidy, academic superficialities. More critical is the fact that the independent, courageously exploratory mind is sometimes slow in its growth, and its slowness in the presence of the agile standard is downgraded to an inferior if not hopeless status.

Is it possible that the superficiality, the dependent conformity and inaction that has been found so typical of young people today, is a condition partly created by education itself and then misunderstood by it? We know that one of the characteristics of healthy plant life is the slow, even rhythm of its development. When its growth is accelerated beyond the pace set by organic imperatives, it develops unnatural but impressive deformities. Its stems will be taller than its healthy neighbors', its branches longer, its leaves larger. But its flower will be pale and puny and its fruit dry and diseased. Human life must surely have its own growth rhythms that cannot be repaced or accelerated without danger of profound organic disruption.

Are we, at this point in human history, going through some kind of wishful transmutation, where human life would renounce its place in the organic world for a new identity intrinsic to a world of its own making? And if this is so has not human life as much to fear from its suprabiological efforts as from the effects of its anti-biological products? Could it be that man is destroying himself in the process of creating his own synthetic cosmos and that the final holocaust, if it ever comes, would only be an anticlimax to the prime tragedy?

Are we beginning to reject our origins in the natural world? Are we forgetting that it is our invention and not our inventiveness that is in reality hurling us through space at thousands of miles an hour, and that we are merely being conveyed along with the rest of the baggage? Does it ever occur to the inveterate motorist behind the wheel of a speeding automobile that he is incapable of moving much faster than four miles in an hour?

How often are our students reminded that the real goal of their frantic educational effort is the total well-being of man himself, a creature whose powers, however fantastically projected, spring from an organism which has remained unchanged through eons of time?

• All works illustrated in this article were done by students in the introductory courses of the Art Department of Brooklyn College.

Is it possible that these powers are being diminished and atrophied by conceptual processes that nourish and utilize only a part of the inherited human potential?

Is our modern laboratory-created cosmos turning out to be, not the brave new world we once anticipated, but the monstrous creation of an undernourished, partly functioning organism?

Can we be sure that the sickness that we diagnose as inertia and indifference in our young might not well be, in truth, the stubborn resistance of healthy human organisms to self-destruction?

And finally, will our present system of education bend to the manifest need and provide for it?

In appraising the vital factors inherent in the mysterious process of human thought most educators at any scholastic level recognize the presence, if not the importance, of visual perception. In the early phases of education, the coordination of optical and verbal-cerebral activity is the prime, functional basis of learning. If questioned, no teacher of the primary grades would deny that learning to read or write, to compute, to comprehend the world geographically, or even, in an elementary sense, scientifically, requires a perceptive eye and the ability to transmute what has been seen into organized symbols of knowledge. Infants incubate visually before they begin to speak. Who has not responded with wonder and a vague respect to the wide-open, preoccupied eyes of a year-old baby who is silently exploring the nature of his surroundings? Yet when the child, after grave preparation, has trained his eye to specific recognitions, his development is appraised on the celerity with which he attaches spoken symbols to them. Visually he may know more about the cat than his father but he is only given credit for his knowledge when he finally gets around to identifying it with a spoken sound. For reasons which I hope will become clear, if they are not already, I believe that the normal child who refuses to be rushed into verbalization and who is slow to learn to talk, prolongs, to his own later advantage, a vital, wordless learning period where experience transcends identities, and the instinct germinates to know before speaking, to give words finally to patient thought rather than thought to impatient words. How many grown men and women in pursuit of truth attempt a return to the impregnable semantic privacy of their infant beginnings—the locked study, the remote cabin, the proverbial ivory tower? From Walden Pond, Thoreau could say: "Perhaps the facts most astounding and most real are never communicated by man to man. The true harvest of my daily life is somewhat as intangible and indescribable as the tints of morning or evening. It is a little star dust caught, a segment of a rainbow which I have clutched."

Education, even in the liberal sense, cannot accept this pessimistic view of the validity of its symbols of communication. Yet it is often forgotten that the harvest must first be reaped before it can be transmuted into an understanding of even the tenuous, inferential knowledge that is poetry.

It is this harvest of the sensory intelligence, gathered largely by the sensibilities, by the eyes in particular, that education, as it proceeds from one stage to the next, ignores, until finally it is all but lost sight of as a factor in the learning process.

Are the symbols of knowledge and our skill with them ever perfected to the point where full comprehension of recorded thought is possible without vivid, referential awareness of the actualities that fathered it? Do we learn or are we merely informed by teaching that confines itself to the recognition of given and unexperienced meanings? How futile to give Thoreau's vision-filling words to the student in freshman English whose unmeditative eye remains unchallenged until he returns in the evening to his television screen.

What have our colleges and universities done to energize, activate and challenge those areas of the total human endowment that can be called *sensory intelligence?* The classic curriculum has always included certain observation disciplines in the laboratories of the physical sciences and on the projection screens of courses in archeology, art history, classical civilization and others. Indeed, with the introduction of audio-visual aids to instruction some scholars would claim a considerable academic concession to the importance of educating the eye. Yet, do not these procedures assume an already educated eye when they limit its learning function to receiving and retaining a prearranged demonstration leading to prescribed conclusions? This, to the eye, is like asking a leading question of the mind and, so far as the eye is concerned, is educationally as valid.

The college professor, selected for his teaching duties by reason of his specialized scholarship and for his mastery of the language of his subject, understandably insists that he cannot undertake to activate and develop the basic faculties and sensibilities. Yet is not the biologist, for example, critically handicapped in his task of revealing the structure of organic life to students whose visual acuity and curiosity have never been seriously challenged by education before entering the biology laboratory?

If the human faculties at the sensory level are indeed a functional essential to the process of learning, and if the education and development of these faculties is not the province of our educational establishment, then where and with whom does this responsibility lie? There is little in today's man-made environment, either in the domestic or public domain, to nourish these faculties, let alone develop them. Occasional visits to the art and science museums, concert halls, the public parks and gardens, cannot be relied upon to awaken sensibilities atrophied and deadened by the realities of daily urban life, like periodic visits to a doctor to restore neglected physical health. Is it enough, under these circumstances, to limit the educational demands upon the eye to the simple ability to recognize and identify? How many college graduates can visually recall more than a hazy abbreviation of a given object when they designate it with a word? And how many have perceptively earned the right to prefix the word *beautiful?* If the overwhelming blight of hopelessly clichéd writing at the college level cannot be overcome by the classical emphasis on syntax and sentence structure or by reference to great works of literature, perhaps the professor of English will finally look to visual education for help in providing the remedy.

What, if anything, has been done or could be done by education to extend the scope of our visual lives and to develop the power of independent and discriminating perception?

The greatest concessions to the importance of visual activity have been made at the grade school level. There are many reasons for this. For one, the role of intelligent perception in the early stages of learning is so manifest that there is little disagreement about the need for extensive and varied visual activity. The so-called "art" classes, "science" field trips to zoos and aquariums, "nature study" in parks and botanical gardens and a host of other look-see activities are undertaken. Primary grade textbooks are now, for the most part, planned and designed for visual as well as verbal comprehension.

Yet these eye-filling programs to a great extent are still basically conceived of as mere aids in the pursuit of conceptual meanings prescribed by the academic syllabus. The child soon learns that the total visual absorption and wonder with which, for example, he confronts a water buffalo for the first time is a private and non-scholastic matter, and that the main issue is to give the beast a name and a habitat, and to spell it all correctly.

It can be assumed that educational visual activity must serve the learning problem and not remain a vaguely purposeless experience. But if there are to be scholastic consequences to exploratory seeing, one of them surely should be the enrichment and not the obliteration of the experience that produced them. The pedagogical anxiety to induce quick mastery of the signs and symbols of communicable knowledge at this early stage, introduces the imbalance between sensory and verbal-cerebral factors that anticipates the almost total emphasis placed on conceptual learning in the high school and college. The well-known complaint at the higher levels that advanced learning is handicapped by early neglect of the communication disciplines may indeed be misdirected. Could it be that the college sophomore writes badly because his education has neglected to nourish in him the experiential sources of good writing in its single-minded pursuit of the means? One of these sources is the province of the thoughtful eye. Without its guidance the road to literacy can become a grammatical exercise and higher learning a vastly inflated kindergarten.

One of the chief obstructions blocking the acceptance of visual disciplines at the college level has been the traditional semantic rigidity of the liberal arts thesis. Over the centuries scholarly authority has prescribed an intellectuality so rigid, and subject matter criteria so categorical, that many of the significant educational innovations of the last half-century have had initially to survive in an atmosphere of academic ostracism. Sacred taboos of ancient origin have stood guard like medieval ghosts over all deliberations affecting not only the content of the curriculum but the precise wording used in identifying and describing it.

Over the years many inroads have been made on the purity of the liberal arts degree, but not without a struggle. No college or university of any standing is without its hard core of orthodox scholars who belligerently defend the covenant of exclusively conceptual scholarship. Whether large or small in numbers, they have always formed the crucible that has qualified—when it has not dictated—all phases of the liberal arts curriculum. Study programs violating the traditional taboos have been either locked out or purposely side-tracked in order to quarantine the heresy. However, by accident, by subterfuge or by overwhelming political pressure, "contaminated" programs increasingly slip through the defenses. One of the renegade areas to gain entrance recently has been the laboratories and studios of the visual arts.

The past quarter of a century has witnessed, here and there, the introduction of accredited elective courses involving the application of the visual and manual faculties. Yet these innovations have been generally consigned to the fringes of academic status and people undertaking them have had to beat a difficult path through the jungle of verbal and semantic properties that protects at least the theoretical integrity of the liberal arts tradition.

Basic to the liberal arts concept, of course, is the taboo on courses of study providing specific preparation and training for immediate vocational practice. This taboo is interpreted in widely different ways by undergraduate institutions. The conservative extreme not only sternly guards the nonprofessional content of its undergraduate curriculum but frowns upon any attempt at elective patterns that too clearly anticipate post-graduate specialization, let alone terminal professionalism. At the other extreme, study patterns directly or indirectly linked to professional objectives are not only encouraged but required, while the heresy hides more or less behind the liberal status of the individual courses and the careful wording of the syllabi and catalogue descriptions.

Visual education at the college level has taken various forms in accommodation to the wide diversity of academic climates. The study of aesthetic theory and the examination of aesthetic tangibles in art are universally acceptable as long as study is confined to appreciation and avoids practice. Lecture courses in the history of art have long been honored by institutions where laboratories or studios devoted to exploratory practices which might sharpen and develop visual and aesthetic awareness have never been permitted. The center of the dilemma surrounding visual education at the college level lies squarely in this prejudicial distinction between thinking and doing.

As long as the eye remains the servant of the scholarly mind there is no problem. The taboo appears as soon as the eye is set free to think for itself and independently to associate itself with the skill of the hand and its tools. Thus, for example, any approach to the phenomenon of color and color relationships has traditionally been limited either to statistical research in the departments of psychology or physics, or to nonacademic easel painting courses in professional schools of art.

Because visual education as such has seldom been allowed to crystallize in any but vocational form, its value to the liberal arts commitment has never been fully approximated. In recent times some institutions have made tentative efforts to find a place for it in their program of liberal studies. In spite of the traditional barriers, here and there departments of art and design have been able to reach the general student with courses which challenge his visual intelligence without the pretext of "art" instruction. Laboratory courses variously labelled *Basic Design, Design Fundamentals, Visual Communication,* etc., have revealed to many the presence of an unsuspected perceptional potential.

The general opinion among scholars in the academic areas is that such courses are worthless to all but students specializing in art. Some admit that these studies might be of limited value to the general student by contributing to his understanding of purely aesthetic matters. But by and large the presence of a positive catalyst serving the *total* human endowment is still unsuspected by the faculty at large, and usually comes as a miraculous surprise to the student himself.

Given the encouragement and the opportunity, how can visual studies serve general education at the college level? It is clear that this question cannot be dealt with in conventional, quantitative terms and still remain within the liberal arts context. Basic visual education will finally have to shed the protective identity of even the vaguest professionalism and demonstrate, in entirely new terms, its value to the educational needs of a dynamic, unadulterated humanism.

The problem to begin with is not curricular. It centers particularly in young humans, living in a specific era which affects them in specific ways, and expects of them a specific way of life and belief in specific values. They in turn expect education to provide the ways and means of not only meeting these demands as social beings but of surviving them as individuals. It is in this survival of unsupported, creative individuality that the exclusively social humanism of conventional higher education has failed and which is the chief concern of the visual workshop.

The general student, when he elects this workshop, is usually unaware of the hazards of this new and strange form of learning. He comes unprepared to meet any demands on his individuality that deny him the comforting support of a ready-made conceptual structure such as other academic disciplines provide. He is eager to know the rules and is dismayed and frightened when he discovers that decision here is not a professional mandate but a matter of personal discipline and judgment. When the student is not unaware of his own visual sensibilities he distrusts them, and expects to be given a blueprint which will chart the course that his eye and hand should take. He misses having recourse to the intellectual generalization. He hardly dares put his hand to the first simple procedural continuum that must do without the guidance of authoritative preconceptions and must depend step by step on the persisting, dynamic awareness of the sensibilities in charge. He begins to draw with the speed of the mind and is quickly lost in visual chaos. He learns to his amazement that the intelligence of the senses has a pace all its own. He discovers that the intelligent, productive eye cannot hop, skip and jump to its conclusions. Visually he has difficulty perceiving more than one thing at a time. He tends, as he did as a child, to imprint island images on a sea of white paper. His eyes, at the start, cannot see the forest for the tree. Details refuse to combine for him into a composite whole. In desperation he begs for "art" instruction, as though he were there to learn how to quote from Manet or Jackson Pollock with the educated skill with which he has learned to quote from Shakespeare or Catullus.

At this point visual instruction is faced with the choice of developing the artificial skills of a purposeless pseudo-professionalism or the more difficult task of providing disciplines that challenge and set in motion each unique visual individuality.

This is a task that can be successfully undertaken only by an experienced artist deeply committed to the aesthetics of vision. His special qualification in this instance is not his technical knowledge nor the applicability of his own professional style of work, but rather that he alone, through experience and creative effort, is conscious of the whole range of complex visual phenomena which give form and meaning to the work of the hands.

How can the student's mind and sensibilities be propelled through experience that will reveal and structure the many facets of his daily visual life and finally bring him the pleasures and satisfactions of independent aesthetic perception?

The general student, almost without exception, comes to the visual workshop not only ignorant of his latent optical powers, but with absurd preconceptions as to the kind and extent of visual effort that can be expected of him. The first and most obstructive block to visual learning is the ingrained assumption that only certain things are worth looking at and that the purpose of visual education is to indicate what these things are—in short to provide a ready-made realm of aesthetic certitude. The very presence of this hopeful belief in a special, visual world composed of elite aspects, as contrasted to the facets of routine daily seeing, defensively rationalizes a permissive adequacy for the lazy eye.

For this reason, the beginnings of the visual workshop are difficult and must provide immediate demonstration that aesthetic elements both in daily life and in art are not self-evident but require an intense and complex visual exertion that cannot be turned on at selected moments like a hot water tap, but must be the normal function of a perpetually inquisitive and perceptive eye. To people blinded by the visual fog of ceaseless conceptual cerebration this requisite appears quite formidable.

The first task, then, is to bring the student to examine varied aspects of common reality with a fresh, unprejudiced eye. Fig. 1 shows a collage of crumpled facial tissue. The problem involves the use of materials not associated with "art". The stated aim is to metamorphose stereotyped recognitions into a state of re-energized and anonymous freshness. Removed from compositional or decorative considerations the emphasis on acute response to things seen opens the way to a subsequent search for and structuring of aesthetic tangibles. The application of controlled light, not for artistic effects, but to intensify and enrich the optical revelation, not only leads to increased and highly catalyzed observational skill but underlines the prime functional requisite for clear aesthetic perception and response.

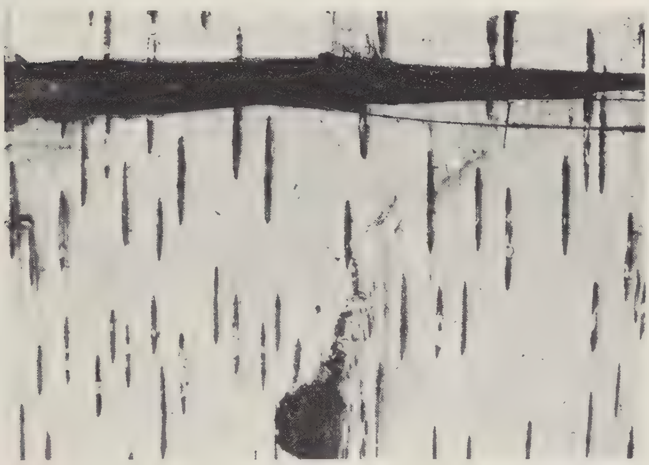
Use of the camera follows preparatory exercises such as this. Photographic processes become tools in the development of visual acuity and often, later, of significant and rewarding attainment. The first steps here, as in all other phases of the basic workshop, involve removal of professional referrals, no matter how excellent, and employ the dark room, the enlarger and the camera simply to reveal and to place in a new frame of reference one's own immediate world. The awakening to the presence of visually exciting phenomena in the arena of everyday life leads from the rubbish collage to a re-examination of familiar but as yet half-seen identities. The bark of the tree (Fig. 2) and the shadow cast on a gravel path (Fig. 3), rediscovered on the ground glass of a camera, are among those artless revelations that indicate not the style or shape but rather the substance of mature aesthetic vision.

The general student brings to his visual problems many ingrained habits of mind derived from the conventions of his educational background. He has difficulty in understanding why these habits should obstruct the learning process here and not in other areas. For example, he fails to make more than a superficial semantic distinction between the written word and the drawn line, seeing them both merely as signs indicative of, but not intrinsic to, a given process of thought. In writing the word *book*, he guides the drawn line through a series of curves and swirls which end in a "drawing" having no intrinsic validity in itself beyond a minimal legibility to provide the mental concept of a "book".

This habit of mind is carried over into the first linear exercises by stubborn student insistence that meaning in linear figurations, as in written words, is implied and not intrinsic. A drawing can be scratched or scribbled and is acceptable as long as what is represented can be identified. Aesthetic experience becomes something extraneous to the drawing itself and central only to whatever concept or image the mind can deduce from the imprinted marks. The teaching effort that struggles to redirect attention away from ephemeral concepts to aesthetic and tactile realities, ironically, is confronted at this point by the defensive "artistic" complaint of being forced from a preferred "realism" into abstraction, even though it has already been emphasized that the "isms" of art are not the province of basic visual studies.

Fig. 4 shows the work of a group of thirty students on a single problem. Each square represents an area of not more than five by seven inches. The assignment was to create value gradations from black to white and to transform the flat white surface into an illusion of space. The procedure was disciplined by limiting the means employed to a series of uniform pen strokes.

1



2

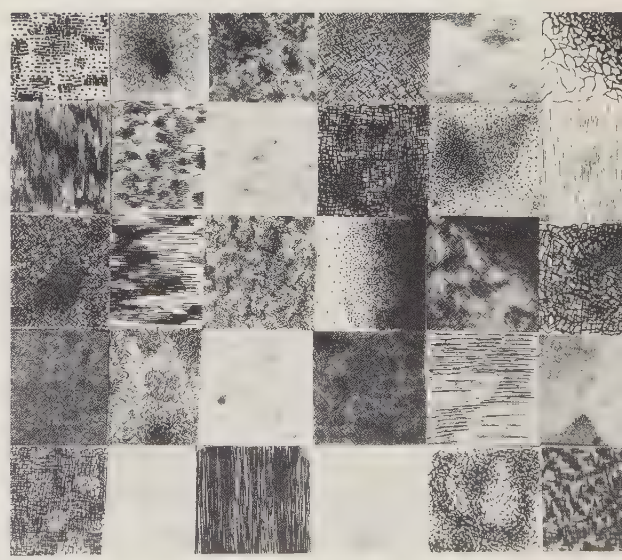
3

Fig. 1. "The aim is to metamorphose stereotyped recognitio
Collage of facial tissue examined photographically
under controlled light.

Fig. 2. "... to place in a new frame of reference
one's own immediate world."
Photographic study of the bark of a birch tree.

Fig. 3. "Photographic processes become tools
in the development of visual acuity."
Photographic study of a shadow cast on a gravel path.

Fig. 4. "... the slow transformation of a dead white surface
into something alive and vibrant."
Pen drawing by thirty different students.



4

The limits of the problem excluded recourse to delineated imagery and in so doing forced the eye to find its satisfactions in the way things were done rather than in what was represented. These small drawings were the result of many hours of experiment and struggle. First efforts resulted in impatient, half-seen, frustrated scratchings. But, it was soon realized that, while the mere recognition of meaning or model might somehow compensate for the absence of visual quality in the written word or the descriptive drawing, there was nothing here but the marks that meet the eye to justify the effort.

The initial problem the instructor faced was to reduce the careless speed of the first pen strokes; and once this was accomplished to require a persisting visual awareness of the marks made as they were being made, involving a continually felt control of the hand by the eye. In some cases the perceptive faculties of touch and sight were so blocked that, in desperation, the instructor suggested tracking the sound of the pen on the paper to induce and maintain awareness and control of the process. (Fig. 5)

One by one, however, these thirty students, each in his or her own way, found the patience to discover the step-by-step development that allowed their eyes and sensibilities to perceive and direct the slow transformation of a dead white surface into something alive and vibrant. Each, after a long self-directed journey reached that destination where wholeness becomes an intimate certitude.

Some of the students involved in these studies move on to more advanced work in drawing, color, photography, wood, clay and metal. Problems in three dimensions present difficulties similar to those already described. For one thing the general student, almost without exception, is unable to perceive the form of a specifically contained volume of space. Reality to him is limited to concrete objects. The space surrounding and containing these objects, no matter how well defined, remains a void beyond the grasp of the perceptive intelligence. A room is not a visibly designed area of space but inconceivable emptiness ending at each wall. Buildings are solid monoliths hollowed out. (Fig. 6)

The student confronts the sculptured object itself with less misgivings than the previous basic exercises. By this time the eye has become sensitized to elements of form, texture, light and other basic tangibles. As long as the three-dimensional task remains confined to the building and structuring of a single, self-enclosed solid there is little trouble. However, difficulties increase when the problem is expanded to include the relationship of more than one solid and introduces the necessity to perceive and to think in terms of space as well as positive form. (Fig. 7)

Fig. 8 shows a group of three related sculptured objects derived from the same basic form. The work is the culmination of a year of experimentation and development. The initial task involved building a solid form in clay and structuring the diverse aspects of its three-dimensionality into a buoyant and equilibrated whole. The tendency to limit perception to the static, two-dimensional aspect of fixed views was generally reflected in the first efforts. The student had difficulty moving around the object and tended to flatten into two dimensions whatever area he worked upon. Planes, instead of uniting into uninterrupted three-dimensional continuity, tended to separate into flat façades.

These difficulties, however, were small compared to the moment when he was asked to build with space as well as with clay and plaster. For this purpose he studied the rough plaster molds from which the solid form had been cast. He was asked to try to bring his powers of perception to the point where the concave emptiness of the molds acquired a presence as tangible as the solid convex object it replaced. Many small models were made as a result of these observations and finally two different concave forms were modeled directly in plaster. The three finished pieces, after painstaking study under various light conditions and in a variety of relationships, were finally secured as seen in Fig. 8.

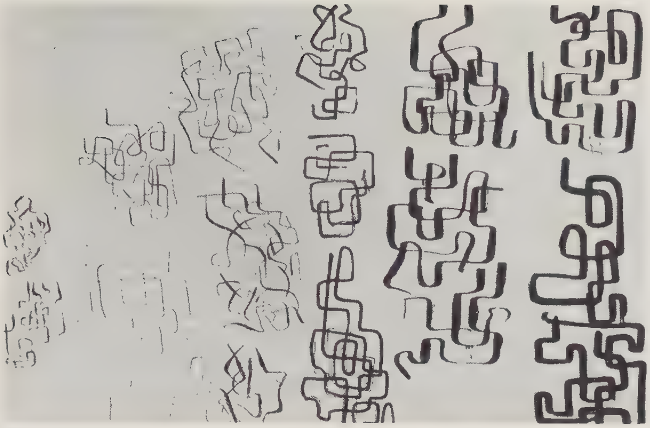
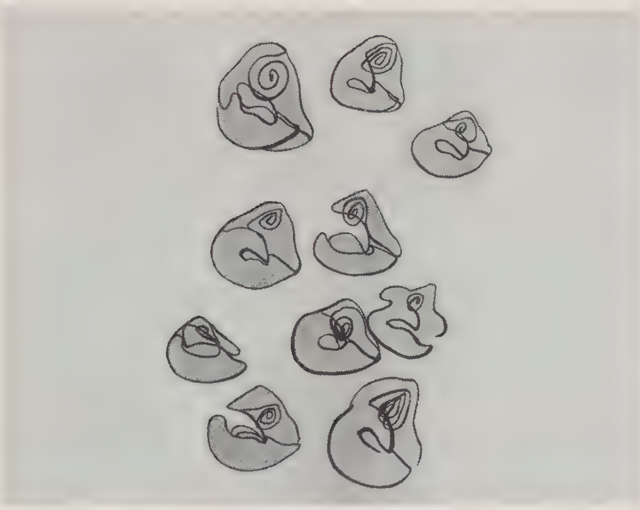

5

Fig. 5. "... a persisting visual awareness involving a continually felt control of the hand by the eye."
Pen studies.

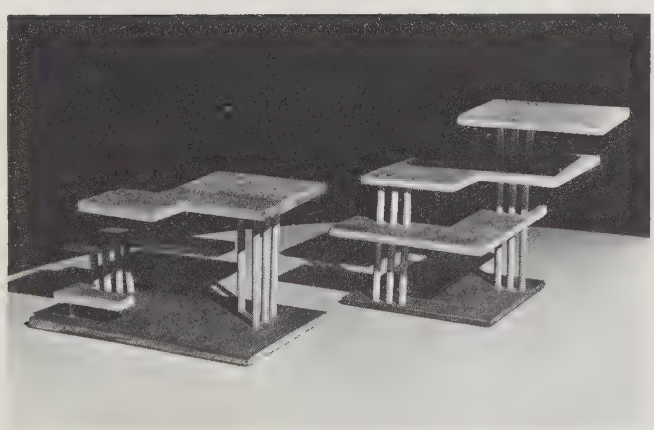
Fig. 6. "... to perceive the form of a specifically contained volume of space."
Pen studies of an "as observed" object.

Fig. 7. "... to perceive and think in terms of space as well as positive form."
Wood constructions.

Fig. 8. "... the concave emptiness of the molds acquired a presence as tangible as the solid convex object it replaced."
Three related plaster objects derived from the same form.


6


8


7

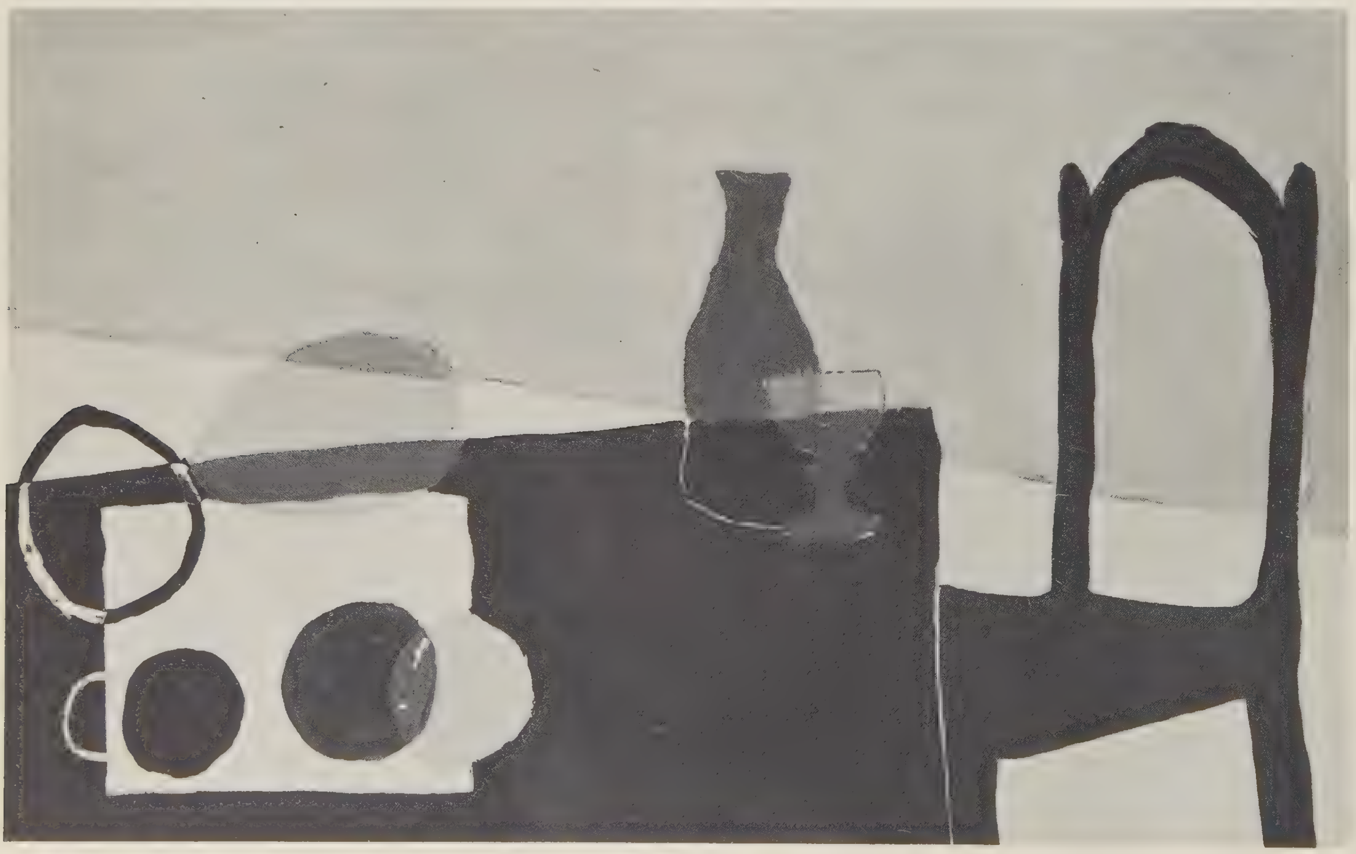
This work symbolizes a visual effort that transforms the chaos of a fragmented reality into the resolved diversity of meaningful unities. There are no practical consequences to this educational experience. What has been learned here is its own reward.

Basic visual education for the general college student can take and has taken many forms. The few examples given here have been chosen to indicate a direction rather than a format.

Whether the goal is the eventual maturation of creative skills or simply mastery of the aesthetically perceptive effort, the first requisite will always be the presence of a fully alive and self-aware sensory intelligence. This requisite cannot be met alone by academic references to ready-made visual and aesthetic phenomena. The first answer lies deep in the perceptive explorations of each lone individual. Surely aesthetic erudition leads nowhere without this experiential base to build on.

Visual education that recognizes the necessity of such beginnings and postpones quantitative considerations until its students can be measured as individuals rather than parrots, is rewarded more often than not with gratifying human consequences. Students discover, before long, that until now they have only half seen what they have looked at, and that they were unaware of their deep need for visual order and equilibrium. They begin to understand the value and the satisfactions of self-propelled action, decision, development and resolution. For many this is the first breakaway from their inbred dependence on authority. Will higher education one day broaden and enrich this adventure in the free exercise of native visual intelligence?

Fig. 9. "... a visual effort that transforms the chaos of a fragmented reality into the resolved diversity of meaningful unities." Gouache painting following basic visual studies.



BIOGRAPHICAL NOTES ON THE AUTHORS

Rudolf Arnheim

Psychologist. Born Berlin. Studied at Berlin University: dissertation on the psychology of visual expression. 1933–38: Associate Editor of Publications, International Institute for Educational Film, League of Nations, Rome. In 1940 emigrated to the United States. 1941–42: Fellow, Guggenheim Foundation. Since 1943: teaching psychology and psychology of art, Sarah Lawrence College, Bronxville, N.Y.; Graduate Faculty, New School for Social Research, New York. 1959–60: Fulbright Lecturer, Ochanomizu University, Tokyo. Author: *Art and Visual Perception* (1954); *Film as Art* (1957); *Picasso's Guernica: The Genesis of a Painting* (1962).

Mirko Basaldella

Sculptor and painter. Born Udine, Italy, 1910. Studied in Venice, Florence, and Monza. 1935–37: one-man shows Galleria La Cometa, Rome, Galleria La Zecca, Turin, Comet Gallery, New York drew valuable critical attention to his work. Since then has had innumerable one-man shows in Europe and the United States. Winner of many international prizes and competitions. Since 1957, Director, Design Workshops, Harvard. Major works: Memorial Gates for Ardeatine Caves; ceiling decoration, Hall of Honor, F. A. O. Building, Rome; Memorial to Italian Dead, Mauthausen, Austria; large bronze for front of Krannert Art Museum, Urbana, Illinois; mosaic fountain, Piazza Benedetto Brin, La Spezia.

Julian Beinart

Architect and city planner. Born South Africa, 1932. Studied at Cape Town University, M.I.T. and Yale. Has taught in the United States and is presently Professor at Cape Town University. In 1960 began running short-term experimental schools in basic design for Africans in Mozambique; has since directed schools in Nigeria, South Africa, Zambia and Kenya. Since 1962 has been directing a research project and working on a book on the popular art of an urban African community in South Africa. Is currently designing college in Bechuanaland. Has written on contemporary African art, architecture and jazz, as well as on general problems of urban form (Zodiac, No. 12).

Will Burtin

Designer. Born Cologne, Germany. Studied design work in graphics, exhibitions, displays and film in Germany and other European countries. 1939–43: taught design and experimental approaches in communication, Pratt Institute, New York. 1943–45: designed gunnery manuals for U.S. Air Force and visual presentation of strategic problems for Office of Strategic Services. 1945–49: Art Director, *Fortune* magazine. 1948: opened studio for visual research and design. Important participating member of many design organizations and activities. Recipient of innumerable design awards. Active contributor to design publications in United States, Europe and Japan.

Anton Ehrenzweig

Psychologist. Born Vienna, 1908. 1928–32: legal and psychological studies, University of Vienna; private studies in arts and crafts and painting. 1938: emigrated to England. 1945–48: worked as colorist in industry. From 1949 on taught in London art schools. At present, lecturer in art education, Goldsmith's College, University of London. 1956–57: Fellow of Bollingen Foundation for research into artistic imagination and creativity. Combines an interest in practical and technical problems of art with a theoretical interest in the depth psychology of perception. Author: *The Psychoanalysis of Artistic Vision and Hearing* (1953).

William J. J. Gordon — Psychologist, scientist and inventor. Studied mathematics and psychology, University of Pennsylvania; bio-chemistry, University of California; physics and psychology, Harvard, where he was a member of the Faculty of the Division of Engineering and Applied Physics. After wartime service he was Research Associate, Harvard Underwater Sound Laboratories. 1951–60: Director, Invention Section, Arthur D. Little. Since then, Chairman of the Board and a Director, Synectics, Inc. Holds patents in fields ranging from bio-chemistry to thermodynamics. Author: *Synectics: The Development of Creative Capacity* (1961).

Bartlett H. Hayes, Jr. — Museum director and educator. Harvard College, class of 1926. Studied art in United States and Europe. Since 1940, Director, Addison Gallery of American Art, Phillips Academy, Andover, Mass. Creator of new educational devices and inventive exhibition techniques. 1952–54: as Chairman, Committee for the Study of the Arts, M.I.T., wrote report, *Art Education for Scientists and Engineers,* published by M.I.T. in 1957. Co-Author: *Layman's Guide to Modern Art.* Author: *The Naked Truth and Personal Vision; The American Line: 100 Years of Drawing.*

Gerald Holton — Professor of Physics, Harvard. Born 1922. A student of P. W. Bridgman, he received his Ph.D., Harvard, 1948. Combines experimental research (properties of materials under high pressure, ultrasonics) with teaching and studies in the philosophy and history of science. 1957–63: editor of American Academy of Arts and Sciences and founder of quarterly journal, *Daedalus.* Currently general editor of new series, *Classics of Science.* Major book publications: *Introduction to Concepts and Theories in Physical Science* (1952); *Foundations of Modern Physical Science* (1958); *Experimental Physics* (1954); *Science and the Modern Mind* (1958).

Johannes Itten — Painter and pioneer in modern art education. Born Switzerland, 1888. 1913–16: student of Adolf Hölzel. 1916: first exhibited his non-objective paintings with the *Sturm* in Berlin. Moved to Vienna where his new teaching methods met with great success. 1919–23: teacher at Bauhaus, Weimar, where he established his renowned *Vorkurs.* 1926–34: headed his own school in Berlin. 1931–38: Head, Textile Design School, Krefeld. 1938–53: Director, Arts and Crafts School and Museum, Zurich. 1943–60: Head, Textile Design School of Zurich Silk Industry. Founded Rietberg Museum of Non-European Art, Zurich, where Director, 1952–55. Author: *The Art of Color* (1961); *Design and Form: The Basic Course at the Bauhaus* (1963).

Gyorgy Kepes — Painter and designer. Born Selyp, Hungary, 1906. 1930–36: worked in Berlin and London on film, stage, and exhibition design. In 1937 came to the United States to head the Light and Color Department, Institute of Design, Chicago. Since 1946 Professor of Visual Design, M.I.T. Author: *Language of Vision; The New Landscape in Art and Science.* Editor of *The Visual Arts Today.* Most active as painter. His works are in the permanent collections of many museums, including: Albright Knox Art Gallery, Buffalo; Museum of Fine Arts, Boston; Museum of Fine Arts, Houston; Museum of Modern Art, New York; Museum of Art, San Francisco; Whitney Museum of American Art, New York.

Tomás Maldonado

Designer and teacher. Born Buenos Aires, 1922. Studied at Fine Arts Academy, Buenos Aires. 1944–54: active participant in new tendencies in art and design in Argentina. 1951: Editor, *Nueva Vision*. Since 1954 associated with Hochschule fuer Gestaltung, Ulm, Germany, where he has been Professor, Vice Director, Head of Foundation Course and Head of Department of Industrial Design and since September 1964, Director. Creative designer for industry and participant in many design organizations and activities. Frequent contributor to major design periodicals.

Wolfgang Metzger

Psychologist. Born Heidelberg, Germany, 1899. Studied Heidelberg, Munich, Berlin and Iowa State Universities. His principal teachers were Max Wertheimer, Wolfgang Köhler, Kurt Lewin and E. M. von Hornbostel. Professor of Psychology and Director of Psychological Institute, University of Münster. Chiefly interested in perception, productive thinking and educational psychology. Author: *Psychologie* (1st edition 1941, 3rd edition 1963); *Gesetze des Sehens* (1st edition 1937, 2nd edition 1953); *Schöpferische Freiheit* (1st edition 1949, 2nd edition 1962).

Robert Preusser

Painter and teacher. Born Houston, Texas, 1919. 1930–47: studied with McNeill Davidson; and at Institute of Design, Chicago; Tulane University, New Orleans; Art Center, Los Angeles. 1942–45: camouflage engineer, U.S. Army. Wide experience as organizer of visual education programs. In 1954 went as Lecturer to M.I.T. where, since 1961, he is Associate Professor of Visual Design, School of Architecture. Most active as painter; innumerable exhibitions in the United States.

Paul Rand

Designer. Born New York, 1914. Studied Pratt Institute, Parsons School of Design, Art Students League, and with George Grosz. Consultant: IBM, Westinghouse and other corporations. Professor, School of Art and Architecture, Yale. Honorary Professor, Tama University, Tokyo. Recipient of many awards and active participant in numerous societies and design organizations. Illustrator: *I Know a Lot of Things* (1956); *Sparkle and Spin* (1957); *Little I* (1962). Author: *Thoughts on Design* (1946); *The Trademarks of Paul Rand* (1960); and numerous articles on design, advertising and typography.

Robert Jay Wolff

Artist and teacher. Born Chicago, 1905. Attended Yale University, 1923–26. Studied art in London and Paris, 1927–31. First one-man show at Art Institute, Chicago, 1935; Nierendorf Gallery, New York, 1936. Has since exhibited frequently in this country and abroad. Collaborated with László Moholy-Nagy and Gyorgy Kepes in founding Institute of Design, Chicago, where he served as Dean and Head of Painting and Sculpture Department, 1938–42. After wartime service, planned, wrote and designed, *The Elements of Design*, a portfolio of teaching panels published by the Museum of Modern Art, New York. Since 1946 Professor of Art, Brooklyn College, Brooklyn, N.Y. Active as lecturer and author of many articles on education and art.

Designed by the arts staff, George Braziller, Inc.
Printed in offset by Connecticut Printers, Inc., Hartford, Conn.