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ELEMENTARY
COLOR

BY

MILTON BRADLEY.

Author of "Color in the Schoolroom" and "Color in the Kindergarten."

WITH AN INTRODUCTION BY
HENRY LEFAVOUR, Ph.D.,
Professor of Physics, Williams College.

Third Edition.

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INTRODUCTION.

The movement in educational reform at present is in the direction of unification. It is held that in framing the programme for any grade the interest not only of the next higher but of all higher grades must be considered. This is done not solely that those who are to enter the higher grades may be directly prepared for their more advanced studies, but especially because it is felt that better work will thus be done for those whose school training is soon to terminate. For the child's education is never finished and a mind rightly directed at the start will gather from its practical experience that with which it may develop and augment the resources and the ideas already received. No education can be sound which teaches anything that is inconsistent with the more advanced truths, however complex and profound those truths may be. There should be no unlearning in the course of an education nor any expenditure of time on that which has no permanent value.

It is of importance therefore to consider in connection with the study of any special subject what the problems are which lie at the end of the educational journey and what basis will be needed in the child's maturer thought. There will thus be the inspiration of the goal to be attained and guidance in the selection of the most helpful methods.

There is scarcely any subject that has so many practical and scientific aspects as the subject of color. Its great importance in the arts and its contribution to the enjoyment of life are matched by [Pg 2] the multiplicity of problems in the physical and philosophical sciences with which it is connected. Without attempting to enumerate all of the scientific problems related to this subject, it may be of interest to briefly summarize those which are most prominent. At the outset we have such purely physical questions as the nature of light, the cause of its emission, the mode of its propagation, the difference in the waves which give rise to the various color sensations, the principles of absorption, of reflection and of refraction, and the nature of material surfaces whereby they acquire their characteristic colors. Then comes the physiology of the eye, including its structure and its function and involving the much discussed questions of primary and secondary colors, and these are closely related to the psychological or psycho-physical study of the nature, duration and delicacy of color vision and color judgment. Next to these comes the study of pigments and of the chromatic effects of their mixture, essentially a chemical and technical question, and finally, the most important of all, the purely psychological or æsthetic problem touching the harmonization and grouping of the various colors and their modifications. The recent advance made in experimental psychology has given an impetus to the study of the whole subject and we may reasonably expect that rational explanations may be found for questions in æsthetics hitherto considered purely arbitrary.

It will be readily seen that there must be a well developed and carefully trained color sense at the basis of an education which is to lead to the consideration of these and similar chromatic problems. As in the development of any special perceptive power, a great deal depends upon making a beginning early in life, when the mind is most receptive and there are no preconceptions to be overcome. [Pg 3] Every means should be employed that will help the child to distinguish between principal colors and between modifications of principal colors. His attention should be directed at as early a stage as possible to the analysis of composite colors and the effects obtained by the combination of colored lights and the results of irradiant light. The principles of chromatic harmony are perhaps not simple, but a child, before whom right standards of color combinations are constantly presented, will acquire a correct æsthetic judgment that may become intuitive. The effect of such a training on the higher development of our people and on their appreciation of true art would be of the greatest value.

If the instruction in color is to be systematic and efficient, it is unquestionable that there must be a simple nomenclature for the standard colors; and for the teacher's guidance at least as well as for the use of the older pupils, a scientifically accurate system of describing any required modification of these recognized standards. The system presented in this book is based on the well-known principle of the Maxwell wheel and has been elaborated by one who has had in view not only the theory of the subject but also the practical possibilities of its use in preparing educational material. This fact, I feel sure, greatly enhances the value of the conclusions at which he arrives.

Henry Lefavour.

Williams College, December 20, 1894.

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PREFACE.

Ever since Newton discovered the solar spectrum it has been referred to in a poetic way as Nature's standard of color. But as soon as the author attempted, some twelve years ago, to use it practically by making pigmentary imitations of the spectrum colors as standards they were decried as vulgar and inartistic. Under such circumstances it was a great pleasure to him to hear a celebrated art professor answer his inquiry if the solar spectrum is the proper place to look for standards of color with the emphatic assertion, "Certainly, there is no other place to go."

Where there are no standards there can be no measurements, and if in color we have no measurements of effects, no records can be made, and hence no comparisons of results at various places and times, and consequently no discussion and little progress. Because there have been no accepted standards and no measurements of color very little has thus far been decided regarding psychological color effects.

In drawing, as at present taught in our best schools from the kindergarten to the university, the foundation of art in black and white is laid in form study. From the drawing teachers we learn that a good touch and a fine sense for light and shade in all their subtle relations to each other are without value, unless due care has been given to the commonplace consideration of lengths and directions of lines, that is to say to the measurement of lines and angles, and to the laws of perspective. We cannot have measurements without standards. By the foot or the metre we measure lines and by the divided circle we measure angles.

[Pg 6] Geometrical forms have already been so definitely analyzed by the science of mathematics that if destroyed today these solids and surfaces could be reconstructed at any future time from written or printed directions. But suppose all material samples of color to be lost, it would be impossible by the ordinary system of color nomenclature to even approximately restore a single one from written or verbal descriptions.

Color is one of the first things to attract the attention of the infant, almost as soon as a sound and long before form appeals to him, so that a collection of colored papers will often prove more interesting and instructive than a picture book to the baby, while the graduate from a two year's course in the kindergarten may have a better color sense than is at present enjoyed by the average business or professional man.

If we could determine the colors used by the great masters in the past, we could add much to our knowledge of the fine arts; and if we knew what colors Chevreul, the master dyer of the Gobelins Tapestry works, refers to in his writings, and which he indicated by hundreds of numbered samples filed away in his cabinet, we should in this generation have a wonderful fund of information to increase our knowledge of harmonies, on which to base our study of color in the industrial arts.

But alas! the paintings of the old masters have faded and the great dyer had no language in which to describe his colors in his writings, and therefore it is claimed that little or no advance in color perception has been made in modern times, if indeed we have held our own. The further assertion is made that those semi-civilized nations whose drawings are the least artistic greatly surpass us in natural color perceptions. If color is the one thing in which we are deficient and in which we are making no advance, is it not necessary that we adopt a new line of operations for our color instruction in the primary grades? It is self-evident that in primary work highest art is not expected in either literature, music, drawing or painting, but as has been the aim in literature [Pg 7]
for a long time and in drawing and music more recently, so in coloring, our instruction should be based on those principles on which highest art must rest.

When through the introduction of colored papers in the kindergartens and primary schools the teachers began to call for better assortments of colors in their papers than were to be found in the market, and some of us in the field attempted to meet their wants, the solution of the problem seemed almost a hopeless task, because no two wanted the same colors; each teacher was a law to herself and one thought a color "just lovely" which another declared "perfectly horrid." According to the early theories then in vogue the first colors called for were red, yellow and blue for primaries, but no two persons were sure just what they wanted for either of these, and there was no authority to be referred to for a decision.

In this strait, which was practically a serious difficulty, the artists were appealed to for a decision as to the three "primary colors," and also for examples showing in what proportions the "ideal primaries" must be mixed to produce the "ideal secondaries." But in this there was no satisfaction because hardly two agreed in the primaries and necessarily the secondaries were much less definite, which was the result that should have been expected.

It is a self-evident proposition that if two indefinite primaries are combined in indefinite proportions the possible secondaries which may thus be produced must be exceedingly numerous, and if this idea is carried out in the production of tertiaries by the combination of the secondaries the resulting colors may be almost infinite. In view of the indifference of the artists and the popular ignorance regarding the subject the solution of this question and the discovery of any solid basis on which to formulate a system of elementary color instruction seemed very problematical. But after much experimenting and many conferences with artists and scientists a basis for operation was decided upon and at the end of fifteen years the efforts begun in doubt [Pg 8]
have resulted in a definite system of color instruction which it is the purpose of this book to concisely set forth.

It is prepared in response to inquiries from primary school teachers for a clear and condensed explanation of the Bradley System of Color Instruction. The aim is to offer a definite scheme and suitable material for a logical presentation of the truths regarding color in nature and art to the children of the primary schools. Much of this instruction is so simple that it should be familiar to children who have had kindergarten training and has therefore already been explained in substantially the same form in "Color in the Kindergarten."

A few years ago it might well have been thought necessary to preface a treatise on the subject with arguments to prove that color is a legitimate object for school instruction, but today this is not a question with thoughtful educators, whether considered from the practical, industrial or æsthetic standpoint. With the establishment of professorships of practical psychology and the equipment of laboratories, provided with delicate and expensive apparatus for making and recording tests, there comes with increasing force the demand for some means by which the experiments in color made in various localities may be unified both as to the colors used and the terms and measurements for recording the result. It is the hope of the author that the system here outlined may be the initial step in gathering together such facts regarding color effects as will form a fund of knowledge little dreamed of at the present day.

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The Theory of Color.

In order to place the study of color on a broad and safe foundation, the work must commence at the bottom with a rational presentation of the subject, based on experiments and the use of color material. We must intelligently consider the relation that exists between the pure science of light which is the source of all color and the use of color materials with their effect on our color perceptions. While it is true in all study that there is here and there found a natural genius in some line of work who seems to have such inborn perceptions as to require little or no logical instruction in his special line, it is also manifest that the masses must gain their knowledge through a systematic presentation of the subject, if they secure it at all. Therefore with the growth of modern pedagogics the laboratory work of the psychologist has become a necessity. This consists in collecting and tabulating the results of hundreds and thousands of experiments regarding any subject under investigation, and the averaging of these to form theories and laws. In making these experiments there must be standards and measurements on which they may be based and some nomenclature in which to make the records; and the standards, measurements and nomenclature adopted must be common to those who desire to compare their results made in different places at different times.

From the results of many physical experiments properly measured and recorded certain psychological theories are deduced. These experiments are tried on hundreds and thousands of individuals and the average results establish the theories, which will ultimately stand or fall according to the truth and accuracy with which the experiments have been made. Experiments [Pg 10] are useless for formulating any exact theories unless they can be recorded in some generally accepted terms for comparison with other experiments made under similar conditions and recorded in the same terms.

So in color perceptions it is not necessary that we know anything of the theories of color in order to see colors, and if endowed by nature with a natural genius for color, education in color may not be necessary, but if there is to be education in color which can be transmitted to a second party there must be some standards of colors and some measurement of color effects which can be recorded in accepted terms.

Why Artists and Scientists Have Disagreed.

In the realm of art there is no necessity for any purely scientific analysis of sunlight, which is the origin of natural colors, because all the practical value of color is found in its æsthetic effects on the mind, and in order to enjoy these even in the highest degree it is not necessary that we understand the scientific origin of the colors, any more than it is necessary for the artist to know the chemical composition of his pigments in order to produce best effects with them on his canvas. Because of this almost self-evident fact, artists have as a rule been very impatient when any reference has been made to the science of color in connection with color education, believing that color is an exception to the general subjects of study to such a degree that it lies outside of all scientific investigations. Consequently they have not been in sympathy with the physio-psychological investigations which have been prosecuted with such promising results in other lines, when such investigations have been proposed regarding color. While it is not essential for best results in his own work that an expert artist shall know anything of the science of color, still if he is to communicate his knowledge of art to any others except his personal pupils, he must have some language in which to make known his ideas, and on the same grounds if any psychological tests are to be made regarding color, it is evident that there must be some [Pg 11] accepted terms in which to record the results, which has not hitherto been the case.

When the well known Newton and Brewster theory of three primary colors red, yellow and blue, was advocated by those scientists there appeared to be something of interest and value in it for the artists also, because with the three pigments red, yellow and blue, they seemed to be able to confirm the truth of the scientific theories regarding the spectrum colors. But the scientists have long been convinced that there is no truth in this theory and have quite generally accepted the Young-Helmholtz idea of three other color perceptions red, green and violet, from which they claim all color vision is produced, and which they call fundamental colors.

This more modern theory has seemed so far removed from the realm of the artists and the colorists that they have not been able to see anything in it of truth or value to them, and so have continued to repeat the old, old story of the three primaries red, yellow and blue, from which the secondaries orange, green and purple are made etc., etc., all of which is the more pernicious when accepted as a correct theory because of its seeming approximation to the facts. And yet there is not in it all any scientific truth on which to build a logical system of color education, and some of the effects which are considered prominent arguments for the system are directly opposed to well known facts in the science of color. Consequently, the artist has failed to gain from the investigations of the scientists anything to aid him in his pigmentary work, and the scientist has not been interested in the æsthetic ideas of the artists which in fact he has generally been unable to fully appreciate, from lack of training and associations.

The system of color instruction here presented for primary grades is based on the results of careful study and experiment for many years in which the attempt has been made to bring the scientist and the artist on to common ground, where they may work in sympathy with each other [Pg 12] instead of at cross purposes as has been the case heretofore, and the results with children have already been such as to testify fully to the efficiency of this line of work.

Thus the feeling for color which every true artist has, may be to a certain extent analyzed so that it can be understood by the scientist and recorded for the benefit of fellow artists one hundred or a thousand miles away and in time an aggregation of facts regarding the psychological effects of color collected which will form the beginning of a valuable fund of color knowledge to be increased from age to age.

The Speculations of the Past.

Ever since Newton produced the prismatic solar spectrum, the so-called science of color as applied to pigments and coloring, has been a most curious mixture of truth, error and speculation. It was supposed by Newton and Brewster that in the solar spectrum the colors were produced by the over-lapping of three sets of colored rays red, yellow and blue. The red rays at one end were supposed to overlap or mix with the yellow rays to make the orange, and on the other side of the yellow the blue rays were supposed to combine with the yellow to produce green.

Following the same theory in pigmentary colors, it has been claimed that all colors in nature may be produced by the combination of pigments in these three colors red, yellow and blue, and hence they have been called primary colors. It is still claimed by the advocates of this theory that from the three primaries red, yellow and blue the so-called secondaries orange, green and purple can be made, and that the secondaries are complementary to the primaries in pairs; the orange to the blue, the green to the red and the purple to the yellow.

By similar combinations of the secondaries it is claimed that three other colors, in themselves peculiar, and different from the first six, may be made, the orange and green forming citrines, orange and violet russets, and green and violet olives and these are called tertiaries. After having [Pg 13] accepted this fiction as a scientific theory for so many years, it is very difficult to convince the artists and colorists that in it all there is nothing of value to any one, but such is practically a fact, because from no three pigmentary effects in red, yellow and blue can the three colors orange, green and purple of corresponding purity be produced, neither are the primary colors complementary to the secondaries as claimed nor are the so-called tertiaries new and distinct colors but simply gray spectrum colors.

Because the red, yellow and blue theory would not stand the test of scientific investigation the Young-Helmholtz theory of three other primaries red, green and violet, has been quite generally adopted by the scientists of the past generation.

What the Primary Teacher Needs to Consider.

All these discussions of the scientists are intensely interesting and no doubt of great importance in the line to which they pertain, but practically neither the artists nor the primary school teachers care for all these theories and discussions and because the scientists have closely confined themselves to these lines, the artists and teachers have seen nothing of value to them in their theories.

In going to the solar spectrum for standards on which to base pigmentary standards, we have given little attention to these various theories in their details, but the one fact of science has received careful attention, namely, that all color effects in nature and art are produced by light reflected from material surfaces. Therefore, inasmuch as the light reflected from any surface must be affected by both the material color of the surface and the color of the light which illuminates the surface, it is necessary that every one having to do with this subject be informed as to what color must be expected to result from given conditions.

In order that this phase of the subject be discussed and thus more fully understood, there must be a terminology or nomenclature in which to express the results produced by given conditions, [Pg 14] and also standards by which to analyze, measure and record these results. In selecting these standards more regard must be given to the æsthetic or psychical effect of the pigmentary standards than to the purely scientific or physical properties of colored light. This selection is of great interest to the physiological psychologist because it is only by the comparison and averaging of thousands of experiments made on different people that valuable theories can be formulated.

With standards and a nomenclature, color will be placed on an equal footing with other subjects, so that perceptions of color effects may be recorded and discussed with much of the definiteness with which we treat form and tone. Because this has not heretofore been possible, comparatively little advance has been made during the last two decades in the æsthetic consideration of material color *which is the only practical phase of the subject*, and if any greater progress is to be achieved in the future it evidently must be along new lines.

From the nursery to the university we are constantly asking two questions, "What is it?" and "Why is it?" and this is what the educator from the Kindergarten to the College is called upon to answer. In his laboratory the psychologist is collecting physical facts by tests regarding the powers of the eye and the ear, the sense of touch, weight, memory, etc., and these experiments when classified, arranged and averaged, furnish a basis for formulating theories, all of which is called psychology.

In vision, form and color play the principal parts, in fact cover the whole ground if we include light and shade in color where it belongs.

Experiments regarding form can be and have long been very definitely recorded but this has not been true with color.

To Frœbel must be given the honor of introducing logical form study into primary education, and on this has been built the present admirable system of drawing in our higher grades of schools, and the introduction of the standard forms in solids and surfaces has brought about a definite use [Pg 15] of geometrical terms by young children which would have seemed very unnaturally mature a generation ago. But in color no corresponding advance has been made because there have been no generally accepted standards in color to correspond to the sphere, cube, cylinder, circle, ellipse and triangle in form, nor any means for measurements to take the place of the foot or metre for lengths and the divided circle for angles.

It is not expected that the children in the lowest grades will learn much of the science of color, but it is desirable that the teachers have such knowledge of it that they will not unconsciously convey to the children erroneous impressions which must be unlearned later in life.

Concerning the Solar Spectrum.

More than two hundred years ago Sir Isaac Newton discovered that a triangular glass prism would transform a beam of sunlight into a beautiful band of color. If the prism is held in a beam of sunlight which enters a moderately lighted room, there will appear on the walls, ceiling or floor, here and there, as the glass is moved, beautiful spots in rainbow colors. If the room is darkened by shutters, and only a small beam of light is admitted through a very narrow slit and the prism properly adjusted to receive this beam of light, a beautiful band of variegated colors may be thrown on to a white ceiling or screen, and this effect is called a prismatic solar spectrum. A perfect solar spectrum once seen under favorable conditions in a dark room is a sight never to be forgotten.

The accompanying illustration shows the relative positions of the parts named. A is the beam of light as it enters the room. B is the triangular prism. The dotted lines represent groups of rays extending to the vertical band of colors indicated by the letters V for violet at the top, then blue, green, yellow, orange to red at the bottom.

The explanation of this phenomenon is that the beam of sunlight is composed of a great number of different kinds of rays, which in passing through the prism are refracted or bent from their [Pg 16] direct course, and some are bent more than others, the red least of all and the violet most. It is supposed that light is propagated by waves or undulations in an extremely rare substance termed ether which is supposed to occupy all space and transparent bodies. These waves are thought to be similar to sound waves in the air or the ripples on the smooth surface of a pond when a pebble is thrown into it. Because so many of the phenomena of light can be satisfactorily explained by this theory, it has been very generally adopted by the scientists. The amount that rays of light are refracted from a straight line in passing through a prism is in proportion to the number of waves or undulations per second, and in inverse proportion to the length of the waves. The red waves are refracted the least and are the longest, while the violet rays are refracted the most and are the shortest.

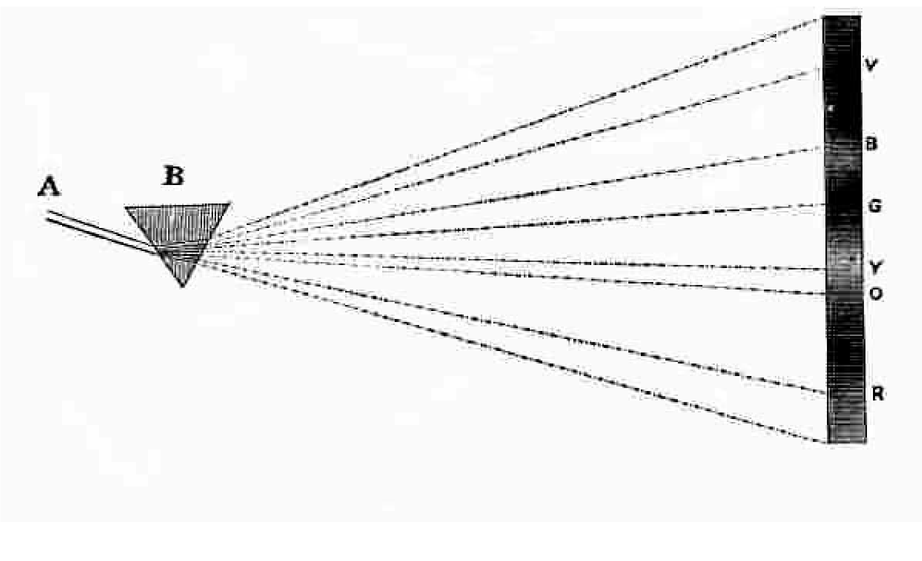


FIG.1

Whether this theory of the spectrum formation is absolutely correct or not, the fact is established that the colors found in a prismatic solar spectrum are always the same under the same conditions and the order of their arrangement is never changed. By means of the quality of spectrum colors called the wave length, a given color can always be located in the spectrum, and hence if a spectrum color is selected as a standard it can always be determined by its recorded wave length.

[Pg 17]

Six Spectrum Standards of Color.

Therefore it seems possible to establish certain standards of color by a series of definitely located portions of the solar spectrum and in the system here presented six have been chosen, namely red, orange, yellow, green, blue and violet. These six are more distinctly recognized than the others, and from them by combination in pairs of colors adjacent in the spectrum all the other colors can be very closely imitated, and hence these six are selected as the spectrum standards. In these standards the most intense expression of each color is chosen i.e. the reddest red, greenest green, etc. which by the closest scientific investigation have been located by their wave lengths so that if they are in doubt in future they can be re-determined by individuals or if disputed, may be corrected by any authoritatively established congress, selected for the purpose. The wave lengths of our six standards are represented by the following numbers in ten millionths of a millimeter. Red, 6571; Orange, 6085; Yellow, 5793; Green, 5164; Blue, 4695; violet, 4210. Having thus scientifically established these unchangeable standards the attempt is made to secure the best possible pigmentary imitation of each.

To any one who has ever compared a piece of colored material with a good presentation of a spectrum color, it is unnecessary to say that the result in an attempt to match the spectrum color with the material or pigmentary color is a very weak approximation, but the one thing aimed at is to secure nearly as possible the same kind of color. For example in the red, it is the aim to obtain the same *kind* of red, by which we mean the same location in the spectrum, i.e. a red neither more orange nor more violet than the reddest spot in the spectrum. This selection must be based on a purely æsthetic perception or impression of color. The same is true of each of the six standard colors, as for example, for orange we select the location which has seemed to a large number of good judges to best represent the feeling of orange as between the quite well defined [Pg 18] red on one hand and the equally definite narrow band of yellow on the other, and it is quite wonderful what unanimity of opinion there is on this particular color which would naturally seem to be the one most doubtful in its location. On the other side of the yellow the green seems to offer little difficulty and the pure Paris or emerald green is very nearly the standard. The violet being at the other end of the spectrum is as easily decided as the red, but the blue between the green and violet is not so easily determined, because, from the best blue the hue runs so imperceptibly into the violet on one side and the green on the other. Pure ultramarine blue is the nearest approach to the spectrum standard of blue of any of the permanent pigments, but even this is a trifle too violet.

For educational purposes papers coated with pigments afford at once the purest colors and the most economical and useful material, and on this plan a line of colored papers has been prepared for color instruction in the kindergartens and primary schools in imitation of the above described spectrum standards.

From the pure spectrum standards it is possible by reflected light to combine the two standards to produce a color between them, for example if two small mirrors are held in a spectrum one at the "red" and the other at the "orange" and the two reflected on to the same spot on a white surface, the result is a color between the red and the orange. So also if we mix red and orange pigments together we may produce colors between the two which may be termed orange-red or red-orange; but unfortunately there is no means known by which we can measure the proportion of the red and orange color-effect which is produced by any given mixture of these two pigments, because color-effect cannot be measured by the pint of mixed paint or the ounce of dry pigment.

The Color Wheel and Maxwell Disks.

We, however, have another means for measuring color effect which just in this emergency seems providential. It is a fact well known to every boy that if he rapidly whirls a lighted stick the fire at [Pg 19] the end produces the effect of a circle of light, which phenomenon is explained by a quality of the eye called retention of vision, by which the impression made by the point of light remains on the retina of the eye during an entire rotation. It is a fact, based on the same quality of vision, that if one color is presented to the eye, and instantly replaced by another the effect is a combination of the two colors. Therefore if one-quarter of the surface of a disk of cardboard is covered with orange paper and three-quarters with red paper, and then the disk placed on a rapidly rotating spindle, the color effect is a mixture of red and orange, and the effect is exactly in proportion to the angular measurements of the two sectors, so that if the circumference is divided into 100 equal parts the resultant color will be definitely represented by the formula "Red, 75; Orange, 25."

Less than forty years ago an English scientist named J. Clerk Maxwell while making experiments with such painted disks happily conceived the idea of cutting a radial slit in each of two disks from the circumference to the center so that by joining the disks they could be made to show any desired proportion of each and hence they are called Maxwell disks. With such disks made in the six pigmentary standards red, orange, yellow, green, blue and violet, the intermediate pigmentary spectrum colors may be very accurately determined by combination and rotation. If we give to each of these standards a symbol as R. for red, O. for orange, Y. for yellow, G. for green, B. for blue, V. for violet, we then have the basis for a definite nomenclature of colors in imitation of the pure spectrum colors. As all pigmentary or material colors are modified by light and shade thus producing in high light tints and in shadow shades of the colors, we must seek for some means of imitating these effects, and fortunately find them in white and black disks. If with a standard color disk we combine a white disk we may have a line of tints of that color, and with a black disk, shades. Giving this white disk a symbol of W. and the black disk N. we complete our [Pg 20] nomenclature. We cannot use B for black because B has already been used for blue, and therefore we use N. for *niger*, the Latin word for black.

The Bradley System of Color Instruction.

Briefly stated then this system of color instruction is comprised under the six general heads: Spectrum Standards; Pigmentary Standards based on the spectrum standards; Maxwell Rotating Disks in the pigmentary standards and Black and White; a Color Nomenclature based on the accepted standards and their disk combinations; and Colored Papers and Water Colors made in accordance with these standards.

For spectrum standards, six definite locations expressing the natural æsthetic or psychological impressions of red, orange, yellow, green, blue and violet are selected. Six standards are chosen instead of a larger number as for example twelve, because for the purpose of a nomenclature the smaller number is more convenient than a greater number. The six are selected rather than three, four or five, because while in the consideration of colored light alone the smaller number would possibly suffice to form by combinations imitations of all other colors, any number smaller than six is entirely inadequate to form by pigmentary or disk combinations fairly good expressions of the corresponding spectrum color combinations.

In selecting the spectrum standards special prominence has been given to the psychological color perceptions of experts in determining those locations in the spectrum best expressing the color feeling of red, orange, yellow, green, blue and violet, while the purely scientific consideration of these several questions has not been ignored or lightly treated.

For pigmentary standards the best possible pigmentary imitations of the six spectrum standards are secured and to these are added the nearest approach to white and black that can be produced in pigments.

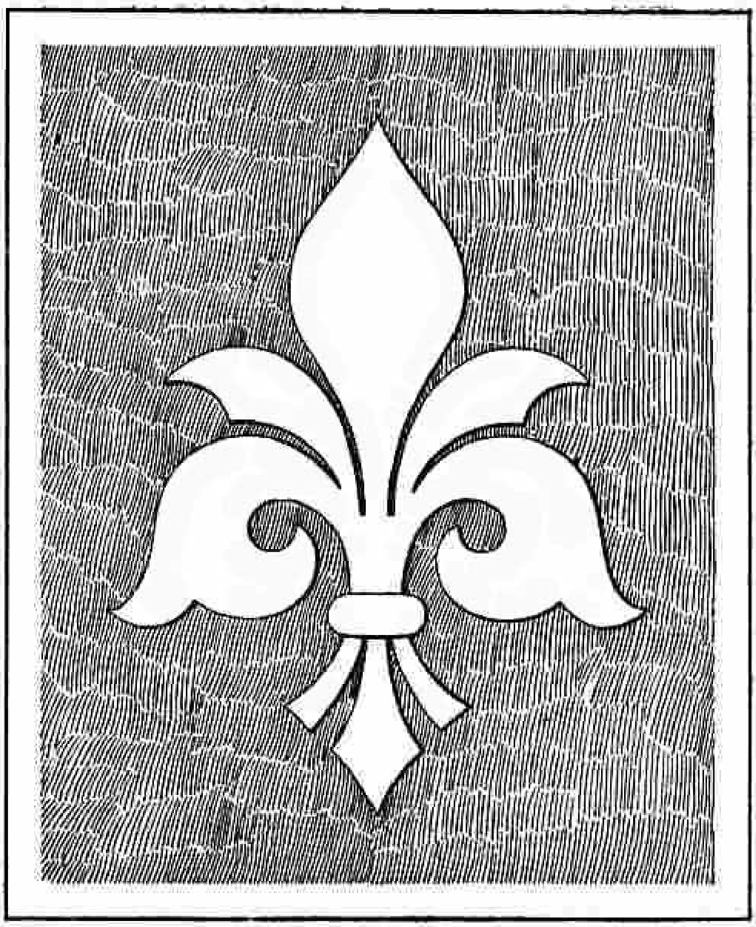
Pigmentary standards on which to base a nomenclature are valueless without some means by which measurements of standards embraced in a given compound color can be expressed. [Pg 21]

The Maxwell color disks are the only known means by which we may measure the relative proportions of color effect embodied in a given color, and therefore the eight color disks are the foundation of the original color nomenclature herein advocated.

Colored papers are chosen for primary color instruction because paper is a valuable medium for simple schoolroom manual training and because no other pigmentary medium is at once so economical and affords such pure colors as may be secured in specially prepared colored papers, without a glazed surface.

Before leaving this part of the subject we do well to remember that in the present conditions of chemistry as applied to the preparation of pigments it is not possible to establish any absolutely definite science of such color combinations. Nor is it possible to establish permanent pigmentary standards without great expense, but if the locations of the standard colors in the spectrum are established by wave lengths the pigmentary standards may be re-determined at any time and produced, in the purest pigments available at the time. In art or harmony effects, the purity of the pigmentary standard is not so important as its hue, i.e. its location in the spectrum, which may always be determined by the established wave length. This last statement may be illustrated by the investigations regarding complementary harmonies. Scientifically one color is not considered complementary to another unless when combined in equal quantities they produce white light, or in other words when combined by the rotation of disks each color must occupy a half circle and the result must be a neutral gray. But this is not essential in considering a complementary harmony, as harmonies in different tones and in various proportions are pleasing and as yet the proportions and tones which produce the best combinations have not been determined.

The entire question of harmonies or pleasing color effects is dependent on individual color perception, and the establishment of rules and laws on these points can result only from a [Pg 22] comparison of the opinions of many experts in various localities and at different times. This cannot occur without some means for recording these opinions in generally accepted terms. It is too late for any individual opinion to be accepted as authority regarding the relative values of two different harmonies in color and this will be still less possible as we become better educated in color and able to sense finer distinctions in color combinations.



[Pg 23]

Color Definitions.

AMONG other advantages to be gained by a logical study of the psychology of color is the establishment of more accurate color terms and definitions. If experiments and discussions based on accepted standards and methods of comparisons can be carried on we may hope in time to have as definite expressions of color terms as we now have in music and literature.

All color terms used by artists, naturalists, manufacturers, tradesmen, milliners and the members of our households are as indefinite as one might naturally expect from the utter lack of a logical basis for the whole subject.

Without definitions or means for intelligently naming any color, it is not strange that the terms used in speaking of colors and color effects are so contradictory as to lose much of their force, if perchance they retain anything of their original meaning. For example, probably most people apply the term SHADE to any modification of a color, either a hue, tint or shade.

It is true that a concise and reasonably full dictionary of color terms must be the outcome of long experience in the logical study of the science of color and its use in our every-day lives, and at the best only suggestions can be made at present. But as there must be a beginning and some terms seem to be fairly well established, the following incomplete list of definitions is offered, always subject to amendment by the majority vote, for whenever such changes indicate advance they should be welcomed.

Ray of Light.—The finest supposable element of light impression in the eye.

Beam of Light.—A number of rays.

Standard Colors.—As used in this system of color nomenclature, the best pigmentary imitation of each of the six spectrum colors red, orange, yellow, green, blue and violet and black and white. These are more specifically called *Pigmentary Standards* in distinction from spectrum standards. [Pg 24]

Spectrum Standards.—The six colors found in the solar spectrum and definitely located by their wave lengths, as follows in the ten millionths of a millimeter. Red, 6571; Orange, 6085; Yellow, 5793; Green, 5164; Blue, 4695; Violet, 4210.

Pigmentary Colors.—All colors used and produced in the arts and sciences. This is in distinction from colors seen in nature, as in flowers and the solar spectrum. The term refers not only to pigments in the strictest sense but to all surfaces coated, painted or dyed artificially.

Pure Colors.—A pure or full color, also called a saturated color, is the most intense expression of that color without the admixture of white or black or gray. All spectrum colors are pure, while no pigmentary color is absolutely pure, but the pigmentary color which approaches most nearly to the corresponding color in the spectrum must be selected as the pigmentary type of purity of that color. For example, the standard for green must be the best possible pigmentary imitation of the spot in the spectrum which by general consent is called green, and so not only for the six standards but for all their combinations which produce the other colors in nature.

In pigmentary colors the term pure is entirely one of relative degree. As processes of manufacture are improved and new chemical discoveries made, there is good reason to believe that we shall have much more intense colors and hence much better imitations of spectrum colors than are at present possible. Therefore as our pigments become purer those now accepted as full colors will in time become tints or broken colors and new standards will be adopted.

Hue.—The hue of a given color is that color with the admixture of a smaller quantity of another color. An orange hue of red is the standard red mixed with a smaller quantity of orange. With the [Pg 25] disks, pure hues are secured only by mixing two standards *adjacent* in the spectrum circuit.

For convenience in speaking and writing about colors in this system of color instruction, all the spectrum colors other than the six standard spectrum colors are designated as intermediate spectrum hues, and often for convenience in speaking of them they are called simply spectrum hues. To these are also added the colors between red and violet which are not in the spectrum. When so used the term must be considered as purely technical in this particular relation, because a color between the standard blue and the standard green is in the abstract no more a hue than either of these colors. If two standards not adjacent in the spectrum circuit are combined the result is not a *pure* spectrum hue but always some *broken* spectrum color.

Local Color.—A term applied to the natural color of an object when seen in ordinarily good daylight and at a convenient distance, as a sheet of paper at arms length, a tree at twice its height, etc.

Tint.—Any pure or full color mixed with white, or reduced by strong sunlight. In the disk combinations a spectrum color combined with white.

Shade.—A full color in shadow, i.e., with a low degree of illumination. In disk combinations a spectrum color combined with a black disk produces by rotation a shade of that color. In pigments the admixture of black does not usually produce as satisfactory shades of a color as may be secured with some other pigments, and each artist has his own preferences in making shades of the various colors on his palette.

Scale.—A scale of color is a series of colors consisting of a pure or full color at the center and graduated by a succession of steps to a light tint on one side and a deep shade on the other.

Tone.—Each step in a color scale is a tone of that color, and the full color may be called the normal tone in that scale. In art this word has had such a variety of meaning as to render it very [Pg 26] convenient for Amateur Art Critics, together with such terms as breadth, atmosphere, quality, values, etc., but in the consideration of color it should have this one definite meaning.

Warm Colors.—Red, orange and yellow, and combinations in which they predominate.

Cool Colors.—Usually considered to be green, blue and violet, and the combinations in which they predominate. But it is, perhaps, questionable whether green and violet may properly be termed either warm or cool. The term cool as applied to colors is quite indefinite, except in a general way, but red, orange and yellow are universally considered as warm, and blue and green-blue as cool.

Neutral Gray.—White in shade or shadow. Pure black and white mixed by disk rotation. Black and white pigments mixed do not usually produce a neutral gray, but rather a blue gray.

Warm Gray.—A neutral gray with the admixture of a small quantity of red, orange or yellow.

Cool Gray.—A neutral gray with a small quantity of blue or green-blue.

Green Gray.—A neutral gray having combined with it a small quantity of green. As this color could hardly be classed with either warm or cool grays this fourth class of grays is suggested as helpful in giving definiteness to the more general color expressions.

Broken Colors.—Gray colors, often improperly called broken tints. For simplicity, a tint of a color is described as the pure color mixed with white and a shade as the color mixed with black, and the corresponding broken color is the same color mixed with both white and black or with neutral gray. A tint of a color thrown into a shadow or a shade of a color in bright sunlight gives a broken color. For various reasons a very large proportion of the colors in nature are broken. Broken colors are much easier to combine harmoniously than full colors, or even tints and shades.

In disk combinations when a pure color is combined with both a white and black disk the result [Pg 27] will be a broken color. When a color is mixed with both black and white, i.e., with gray, and becomes thereby a broken color, it then belongs to a broken scale and educationally has no place in any pure scale, i.e., a scale in which the key tone is a pure color. Neither has a broken scale of a color any place in a chart of pure scales or spectrum scales.

Neutral Colors.—A term often improperly applied to grays, white, black, silver and gold. See passive colors.

Passive Colors.—A term suggested as covering black, white, silver, gold and very gray colors. The term "neutral colors" is often used in this sense but this is evidently improper if we are to confine the term "neutral gray" to the representation of white in shadow because as soon as a gray has any color in it, it is no longer neutral.

Active Colors.—Those colors neither passive or neutral. Necessarily both the terms "active" and "passive" used in relation to colors must be quite indefinite.

Complementary Colors.—As white light is the sum of all color if we take from white light a given color the remaining color is the complement of the given color. When the eye has been fatigued by looking intently for a few seconds at a red spot on a white wall and is then slightly turned to the wall, a faint tint of a bluish green is seen, and this is called the accidental color of the red, and is supposed to be identical with its complementary color. If with the disks we determine a color which with a given color will produce by rotation a neutral gray, we have the complementary color more accurately than by any other means at present known in the use of pigmentary colors.

Harmony.—Two colors are said to be in harmony or to combine harmoniously if the effect is pleasing when they are in juxtaposition or are used in a composition.

Spectrum Circuit.—If a pigmentary imitation of the solar spectrum with the addition of violet red [Pg 28] at the red end and red violet at the violet end be made, and the two ends joined, we shall have a spectrum circuit. This may be in the form of a circle, an ellipse or an oval.

Primary Colors.—In the Brewster theory red, yellow and blue. In the Young-Helmholtz theory red, green and violet are termed primary colors because it is supposed that from these three sensations all color perceptions are experienced. In purely scientific investigations of color perceptions these last three or others which are supposed to serve the same purpose are also called fundamental colors. Practically every spectrum color is a primary, because each has its own wave length.

Secondary Colors.—In the Brewster theory orange, green and purple have been called secondary because it is claimed that they are produced by the combination of primary colors in pairs.

Tertiary Colors.—A term used in the Brewster theory to denote three classes of colors called russet, citrine and olive, made by mixing the secondaries in pairs. These are all broken spectrum colors. The orange and purple produce russet; the orange and green form citrine; the green and purple, olive. There seems to be no good reason for perpetuating the indefinite terms secondaries and tertiaries as applied to color.

Values.—This word is very freely used in discussing effects in works of art, both in color and in black and white. At present it seems to be a very difficult term to define, and yet each artist is quite sure that he can "feel" it, although few will attempt to put into words a definition satisfactory even to themselves. When an engraver, who is also an artist, attempts to interpret nature in black and white on the metal plate or wooden block, he endeavors to reproduce the "values" of the various parts of the subject before him. In doing this he, for one thing, attempts to produce a variety of neutral grays which will express to the eye by means of black and white lines the same tones of color effect as are seen in the several parts of the subject under investigation. If this were the whole problem the matter would be easily expressed by the disk nomenclature. [Pg 29] For instance, if we are to consider a certain red object which may be represented by the standard red disk, we place a medium sized disk of that color on the spindle, and in front of it, smaller disks of white and black united. By rotation the white and black disks become a neutral gray at the center of the red disk. If this gray is made nearly white all observers will agree that the gray is lighter than the red, and if it is nearly black the opinion will be equally unanimous that it is darker than the red. Consequently there evidently must be a gray somewhere between these two extremes which a large majority of experts may agree to be equal in depth or tone to the red, i.e., neither lighter nor darker. But the artist-engraver will insist that to him the term "value" expresses much more than this and that he must use different lines in the sky or distance from those which he uses in the foreground; and some engravers will also insist that two different colors in the foreground must receive different treatment with the graver in order to express their true values. We know that true values of colors are not expressed in a photograph, as the warm colors are too dark and the blue far too light. If the term "value of a color" is to be used as expressing something more than a neutral gray of such a tone as to seem equal to it, then possibly this latter quality must be expressed by the word tone, and yet this use of that word will seem to enlarge its scope beyond its present limits as it now is used to express the relations between the different localities in *one* scale of color, while this new use will extend to the comparison of tones in various color scales, including neutral grays.

Luminosity.—The luminosity of a color is determined by comparing it with a neutral gray. When a color seems to be of the same brightness as a given neutral gray, i.e., not lighter nor darker, then that gray is its measure of luminosity.

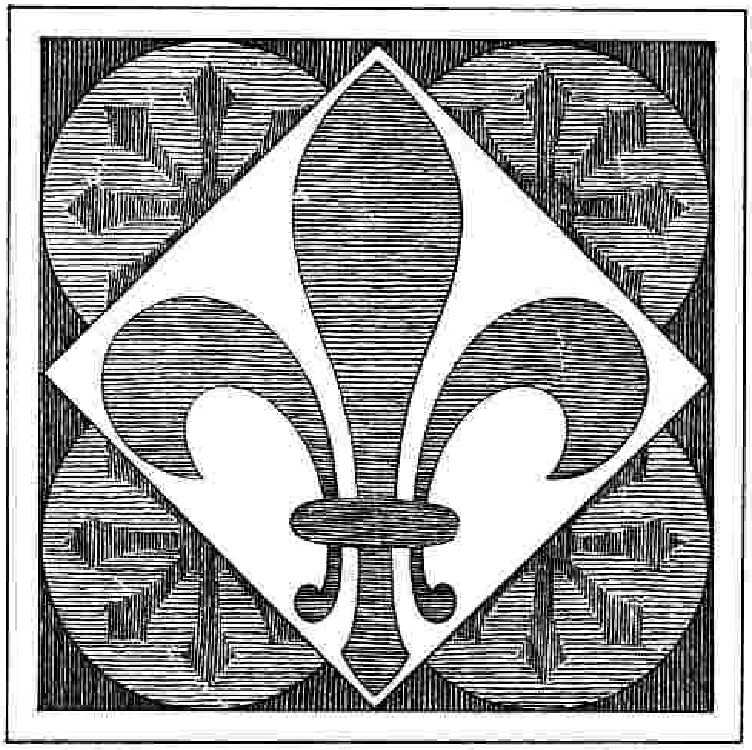
A noted authority says: "No colored object can have the luminosity of a white object reflecting practically the whole of the light impinging upon it. Therefore if we take absolute reflection as [Pg 30]

100 a fraction of 100 will give the relative luminosity of any body." Luminosity is another expression of the quality above described as forming a prominent feature in the term values.

Potentiality.—The ability or strength of a color to affect other colors by combinations with them. For example, white has a greater potentiality than black, yellow greater than red, and violet the least of all the spectrum colors.

It is a pertinent question whether any quality is involved in this term which is not found in value, tone and luminosity, but it expresses a somewhat different phase of a line of color effects.

Quality.—This term seems to be used rather indefinitely when applied to color, but perhaps it is not far removed from the term hue or kind of color.



[Pg 31]

Practical Experiments

Illustrating the Theory of Color.

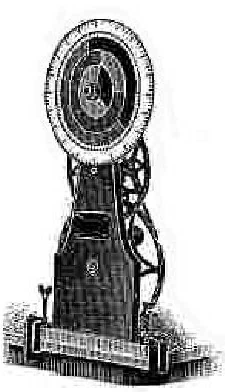


Fig. 2.

In the foregoing pages an attempt is made to explain clearly and as briefly as possible the principles on which the Bradley system of color instruction is based, and also to suggest a few definitions necessary to an intelligent discussion of the general subject of Color. Owing to the peculiar nature of the questions involved, demonstration by actual experiment is more convincing than the mere statement of theories can possibly be, and therefore a few of the following pages will be devoted to the explanation of some valuable experiments, all of which may be tried by the teacher in private, while many of them can be shown the pupils with great advantage.

In this system the Maxwell color disks are the means for color combinations and the basis for measurements, and therefore for a color nomenclature. For this reason the present chapter treats largely of the proper use of the wheel and incidentally the theory of red, yellow and blue primaries with combinations to produce secondaries and tertiaries. No teacher using the material connected with this color scheme can hope to meet with success without a knowledge of the principles on which it is based, and in this subject as in all others, it is essential that the teacher shall know much more of it than he or she is ever required to teach.

The Color Wheel.

For most convenient use the machine should be clamped to the front of a table and near one end, so that the speaker using it can stand at the end of the table and operate it with the right hand. Fig. 2 represents the Normal School [Pg 32]

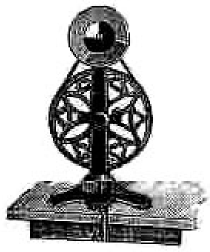


Fig. 3.

Color Wheel showing the face of the disks as seen by the audience. Facility in the operation of the Color Wheel is rapidly acquired by practice and the exact position is easily determined by the operator after a few trials.

Fig. 3 shows the Primary School Color Wheel, which has only two sizes of disks, while the largest machine has four sizes and is much finer in construction. The smaller machine does not require clamping to a table, but may be steadied by the left hand while being operated by the right hand.

The Color Top.

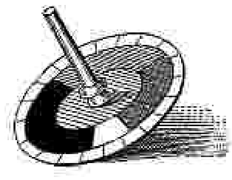


Fig. 4.

Many of the experiments of the color wheel can be produced with a small toy called a Color Top, which is shown in Fig. 4. It is composed of a thick cardboard disk forming the body of in the operation of the Color Wheel the top and a central wooden spindle on which the disk closely fits. A number of colored paper disks are provided with this top so that very many of the experiments performed before a class can be repeated individually by the pupils and in this way the facts which may have been demonstrated to the class with the color wheel can be fixed in the minds of the pupils by their own experiments with the top. Also as a home toy in the hands of the pupils it can be of value, not only to the children, but to the parents as well.

Use of the Disks.

Fig. 5 shows the method of joining two Maxwell disks and Fig. 6 their appearance when properly joined to be placed on the rotating spindle of the color wheel. In joining two or more disks for use on a color wheel or top, care should be taken to place them in such relation to each other that [Pg 33] when rotated the radial edges exposed on the face toward the audience will not "catch the wind." With small disks on the color wheel this is not important, and if there is no whole graduated disk on the arbor behind the slitted disks there is no advantage, but in using the larger disks it is well to put the graduated disk behind the others for this purpose, as at best it is quite laborious to keep up speed when using several of the large disks, even with the best possible conditions. With the thin paper disks of the color in the operation of the Color Wheel top this is an important matter. It will be noticed that the method of joining the disks for use on the Color Top is the reverse of that to be observed with the disks of the Color Wheel as shown in Fig. 5.

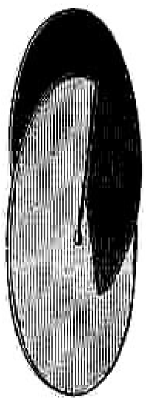


Fig. 5.

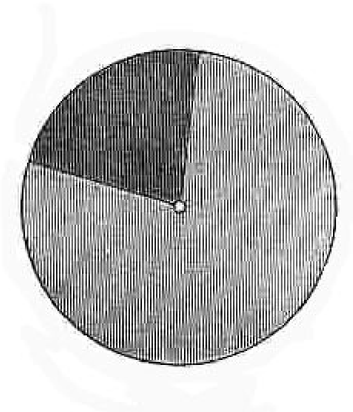


Fig. 6.

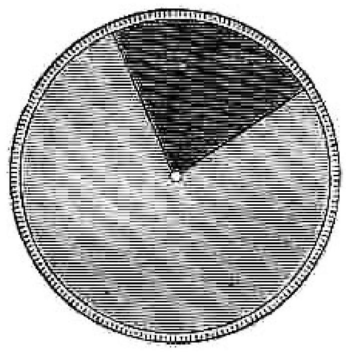


Fig. 7.

Fig. 7 shows the same two color disks placed in front of a large white disk having its edge graduated to one hundred parts, so that the relative proportions of two or more colors to be combined can be determined accurately.

As the smaller disks offer so much less resistance in rotation than the larger ones they are most desirable in private experiments or before a small class, and the largest disks of the Normal School Wheel are necessary only when more than three expressions of color are required to be shown at the same time. In making experiments before an audience those persons in front should if possible be at least ten feet from the color wheel. From ten to forty feet there seems to be but [Pg 34] little difference in the color perception, but for best tests fifteen to twenty feet is the most desirable position.

For private practice with the color wheel a small mirror may be placed five or six feet in front of the wheel in such position as to furnish an image of the disks to the person operating the machine. Owing to a slight loss of light by reflection the closest criticism may not be possible when working with a mirror in this way, but if a plate mirror is used the results are very good and a bevel plate mirror about 7 x 9 inches without frame, can usually be procured at small cost; this method is much more satisfactory for personal experimenting than an assistant to turn the wheel.

These disks have heretofore been used as a curious piece of philosophical apparatus rather than because they have been supposed to have any practical value in color training, but in establishing a color nomenclature based on six spectrum colors the disks at once assume a great value and are indispensable in a system of color instruction founded on the science of color and on the psychological perception of colors.

Let us suppose that the two disks shown in Fig. 7 are yellow and green, 80 parts yellow and 20 parts green; then by rotation we shall have a green yellow indicated by the symbol Y. 80, G. 20. No argument is necessary to prove that when an exact expression of color effect is required this is better than the simple statement that it is a greenish yellow.

How to Begin the Experiments.

For practice it is profitable to commence with the red and orange disks combined on the spindle, with a smaller red disk in front of them, the smallest being preferable. Begin by introducing say five per cent of orange and notice that a change from the standard red at the center is visible. Gradually increase the orange until it seems difficult to say whether the resulting color is more like red or orange, and then exchange the small red disk for an orange disk of the same size, and continue adding orange in the larger disks until the difference cannot be detected between the [Pg 35] small disk and the larger combined disks.

The standards may be combined in pairs, as has been indicated with the red and orange, to produce all the intermediate hues throughout the spectrum, but it must be remembered that these combinations are to be made by joining in pairs, colors adjacent in the spectrum, red and orange, orange and yellow, yellow and green, green and blue, blue and violet. We then shall have representations of all the spectrum colors, but there are still the colors between violet and red, known in nature and art as purples, which must be produced by uniting the red and violet disks, thus completing a circuit of colors containing all the pure colors in nature.

In nature all colors are modified by light and shade, strong light producing tints and shadows more or less deep forming shades.

These effects are imitated on the color wheel by the use of a white disk combined with a disk of a standard color for tints and a black disk for shades, and can be tested in the same order as indicated for the hues, by combining each standard disk with a white or a black disk in varying proportions. It will be noticed early in disk experiments that a very small amount of white produces a decided effect in the tone of a color while a comparatively large amount of black is necessary to produce a marked change. As this is exactly the reverse of the effects of white and black pigments it is always a subject of remark. In pigments these effects are imitated by the mixture of white with a color to produce tints, and black for shades, or more generally instead of black some dark natural pigment approaching the hue of the color, may be preferred because a black pigment will too often impart an unexpected and undesirable hue to the color. As for example, in making shades of red some natural brown pigment is better than black, and so various dark browns and grays are used for different colors. Even with the disks it is impossible [Pg 36] to imitate purest tints of all the standard colors, because in some of the colors, as peculiarly in red and blue, the rotation of the white disk seems to develop a slightly violet gray, for which effect there has as yet been no scientific explanation. This gray dulls the purity of the tint as compared with that which is found in the color under a bright illumination, but on the whole both tints and shades as well as the hues can be better illustrated with the disks than in any other way, and in addition, the advantage is secured of being able to measure and record the tone by the graduated disk in the same way as the hues are measured and recorded. A further advantage is secured in the use of disks in color instruction because with pigments, the only other method by which colors can be combined, much time must be lost not only in the mixing and applying of the colors but in the delay necessary to allow them to dry before the true results can be seen.

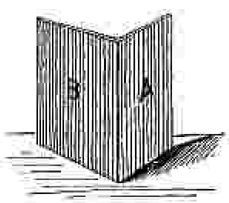


Fig. 8.

The shades of yellow as shown on the wheel will not be generally accepted without criticism, but careful comparison with yellow paper in shadow will prove the substantial truth of the disk results. This experiment may be tried as follows: Join two cards with a hinge of paper or cloth to form a folding screen like the covers of a book as in Fig. 8. On the surface A, paste a piece of standard yellow paper and on B, a piece of yellow shade No. 1. Hold these two surfaces toward the class in such a position that the strong light will fall on B, which is the yellow shade, and thus bring the face A, which is a standard yellow, in a position to be shaded from the light. By varying the angle of the covers with each other and turning them as a whole from side to side, a position will be secured in which the two faces will seem so nearly alike as to convince the class that this color which they may have [Pg 37] thought to be green, is not green, but a color peculiar to itself, a shade of yellow; because the darker paper when in full light appears substantially the same as the standard yellow in the shade or shadow.

In our experiments thus far with the wheel we have combined the standards in pairs to produce the colors of the spectrum between the standards, which for convenience may be called intermediate spectrum hues, and also have combined a white disk with each of the standards to produce tints of the standards and a black disk to make shades.

By combining a white disk with an orange and a yellow disk, for example, forming a trio of disks, a variety of tints of orange yellow and yellow orange may be made. Also by the use of the black disk instead of the white a series of shades of the intermediate hues may be produced, and thus a great variety of tints and shades of many spectrum colors shown.

Now if the white and black disks are combined with each other the result will be a shade of white, i.e., a white in shadow, which is an absolutely neutral gray. As the experiments progress it will be seen that this neutral gray is a very important feature in the study of color, and therefore it may be well at this point to make sure that the disk combinations give the true gray of a white in shadow by a test similar to the one used for the shade of yellow, thus disarming criticism. Such a test may conveniently be made by covering the reverse sides of the folding covers with white on one cover and "neutral gray paper No. 1" on the other. As the neutral gray papers are made in imitation of combinations of black and white disks this experiment is as convincing as the one regarding the yellow shade. This is but one of many examples of the value of disk combinations in the classification and analysis of colors.

In an elaborate chart of colors highly recommended for primary color instruction a dozen years ago no correct understanding of the classification of colors is shown, the tints and shades being indicated by a very decided change of hue rather than a consistent modification of tone. For [Pg 38] example, in the red scale the standard or normal red is vermilion, i.e., an orange red; shade No. 1 is simply a red less orange in hue than the standard, and shade No. 2 a shade of the standard red advocated in this system; while tint No. 1 is a broken yellow orange and tint No. 2 is much more yellow and more broken than No. 1.

Similar inconsistencies occur in all the other scales, showing that the author had no correct knowledge of the analysis of colors, and yet this was the best and practically the only aid offered for instruction in color at that time.

Neither were there any true standards for neutral grays and the term "neutral" was used in such an indefinite way as to rob it of all actual value, until by the aid of disk combinations it came to be confined to white in shadow as closely imitated by the combinations of white and black disks.

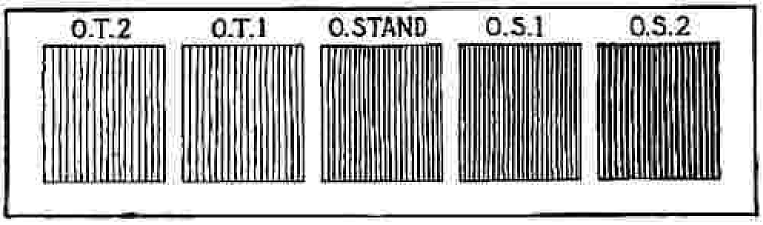


Fig. 9.

With colored papers made in imitation of the six standards and two tints and two shades of each, six scales of colors may be produced by arranging the five different tones of each color in a row, as in Fig. 9, which represents the orange scale with tints at the left and shades at the right. If, in addition to these six scales, we have two scales between each two of the standards, we may have between the orange scale and the yellow scale a yellow orange scale and an orange yellow scale, and if we thus introduce the intermediate scales between each of the other two standards, and include the red violet and violet red, we shall have eighteen scales of five tones each.

The eighteen scales as above named may be arranged as shown in Fig. 10 to form a chart of pure [Pg 39] spectrum scales which is very valuable for study and comparison and especially so in the study of the theory of harmonies. All these tones are called pure tones and this chart is therefore called a chart of Pure Spectrum Scales.

The idea that soft, dull, broken colors produce best harmonies when used in combination may or may not be a universally accepted truth, but there is a general belief that it is much easier to make acceptable combinations with broken colors than with pure spectrum colors and their tints and shades, and therefore the temptation has been strong to select a general assortment of colors which easily harmonize because of the pleasing effect, instead of having regard solely to the educational value of colors.

Truth in education requires that when colors are classified as spectrum colors they shall all be the nearest approach possible to the true spectrum colors, and in the spectrum there are no broken or impure colors. Therefore, whenever the spectrum is set up as nature's standard or chart of colors and an imitation is made in pigments or papers, great care should be used to secure the most accurate imitation possible, but in the past this has not been the case, because of the prevailing idea that the colors must all be possible combinations of three primaries, and hence the orange, green and violet have often been very broken colors. While pure colors and their tints and shades may be advantageously combined with various tones of broken colors in one composition for artistic effect, they should be definitely divided when classified for educational purposes, and their differences clearly explained to students.

In a scale of tones in any color the several papers will harmonize more easily if the tints and shades are not too far removed from the standard, but it is thought by many good judges that the educational advantage in learning to see the relationship of color in the more extreme tones is of greater importance in the elementary grades than the facility for making most pleasing [Pg 40] combinations. Consequently in the Bradley colored papers the tints are very light and the shades quite dark.

If, instead of adding either a white disk or a black disk to a spectrum color, by which we make pure tints and shades, we add both white and black, a line of gray colors or so-called broken colors is formed. This is most beautifully shown with the disks, and in this way a line of *true broken colors* is secured, because in each case a true neutral gray has been added to the color, which cannot be insured in the mixture of gray pigments. As an example, this may be shown with the three smaller sizes of the orange disks. With the medium size of these three make the combination Orange, 35; White, 10; Black 55. With the larger size disks make the proportions Orange, 16; White, 5; Black, 79, and with the smallest size Orange, 43; White, 33; Black, 24. Place these three sets of disks on the spindle at one time and you have the three tones of a broken orange scale.

With similar combinations applied to the six standards and one intermediate hue between each two, there will be material for a chart of Broken Spectrum Scales, as shown in Fig. 11, including twelve scales of three tones each. These are the most beautiful colors in art or nature when combined harmoniously. Because of the loss of color in broken colors it is not advisable to attempt so many different hues or so many tones of each hue as in pure colors, for slight differences in either hues or tones are not as readily perceived.

In these two charts of color scales two distinct classes of colors are represented, namely, pure colors and broken colors. The pure colors consist of the purest possible pigmentary imitations of spectrum colors, with their tints and shades, and the broken colors are these pure colors dulled by the admixture of neutral grays in various tones. This distinction is readily recognized under proper training, so that if a broken color is introduced into a combination of colors from a pure scale it will be readily detected, which always occurs when the attempt is made to produce a series of spectrum scales by the combination of the three primary colors red, yellow and blue. By this method, if logically carried out, the orange, green and violet are dark broken colors, and hence to a less extent the intermediate colors also, because each of these is a mixture of a pure color with a broken color. The usual result, however, is that the orange made from the red and yellow seem so out of place in the warm end of the spectrum that it is modified and made much nearer the pure color, usually, however, too yellow, while the greens and violets, which are deep and rich broken colors, may seem more harmonious, but are so dark as to be out of place among spectrum colors.

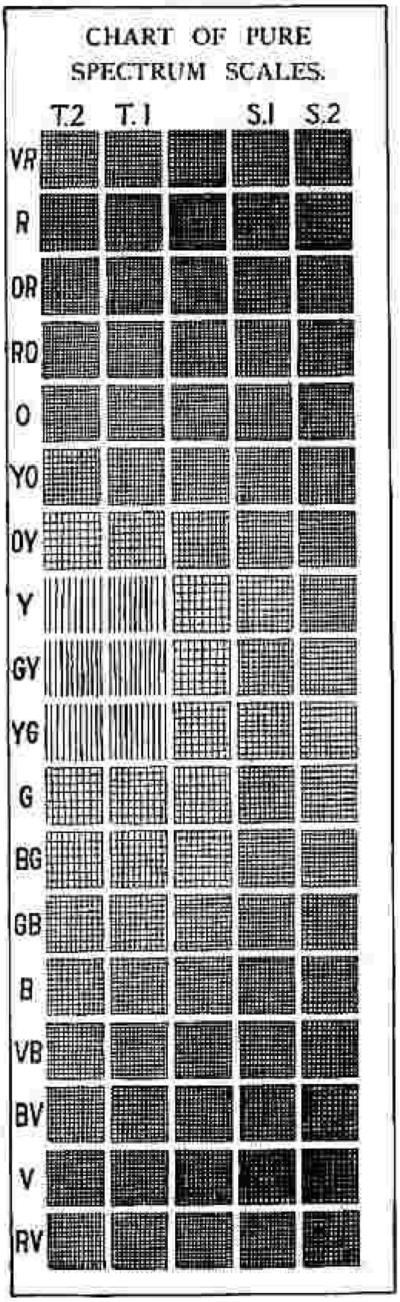


Fig. 10.

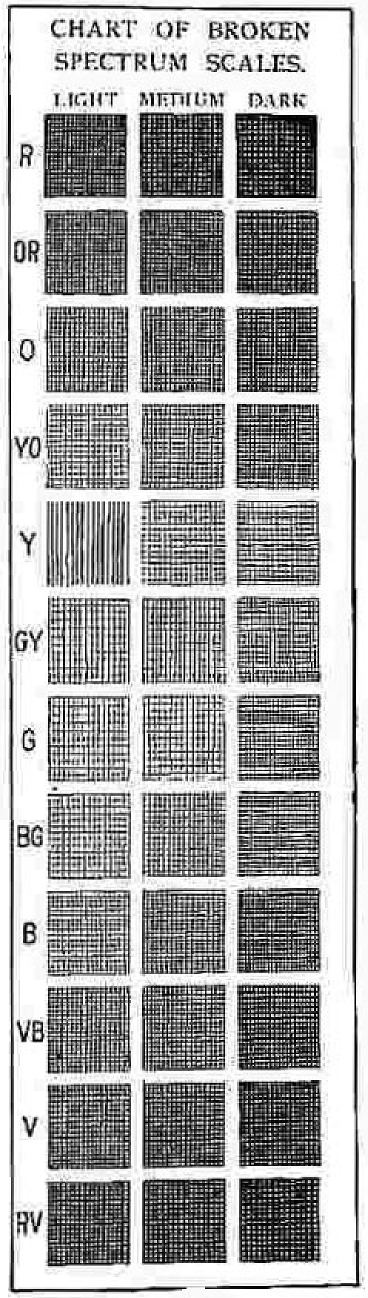


Fig. 11.

If light broken colors are properly combined a beautiful imitation rainbow is produced, which is more harmonious than the spectrum made from full colors. A series of such colors combined in spectrum order produce a more pleasing effect when separated by a small space of white, black, gray, silver or gold. The reason for this may be found in the discussion of simultaneous contrasts. [Pg 42]

In nature nearly all colors are broken. First, there is always more or less vapor together with other impurities in the air, so that even in a clear day objects a few hundred feet from us are seen through a gray veil, as it were, and in a misty or hazy day this is very evident. In the case of somewhat distant foliage the general color effect is produced by the light reflected from the aggregation of leaves, some of which may be in bright sunlight and others in shadow, with a mixture of brown twigs. All these tints and shades of green and brown are mingled in one general effect in the eye. Also, owing to the rounded forms and irregular illumination of objects, we see very little full or local color in nature.

Therefore the study of broken colors becomes the most fascinating branch of this whole subject, and it also has an added interest because nearly all the colors found in tapestries, hangings, carpets, ladies' dress goods, etc., come under this head. In fact it would be hazardous for an artisan or an artist to use any full spectrum color in his work, except in threads, lines or dots. A [Pg 43] considerable quantity of pure standard green, for instance, would mar the effect of any landscape.

It is a very interesting diversion to analyze samples of the dress goods sold each season under the most wonderful names. For example:—

"Ecru," a color sold a few seasons ago, is a broken orange yellow with a nomenclature O. 12, Y. 15, W. 17, N. 56, while this year "Leghorn" and "Furet" are two of the "new" colors, the former having a nomenclature of O. 16, Y. 54, W. 19, N. 11, and the latter O. 18, Y. 18, W. 8, N. 56, all of which are very beautiful broken orange yellows.

"Ashes of Roses" of past years is a broken violet red which can be analyzed as follows: R. 8-1/2, V. 2-1/4, W. 15-1/4, N. 74.

"Anemon" of this season is R. 28, V. 7, W. 5, N. 60, which is another broken violet red.

"Old Rose" is a broken red: R. 65-1/2, W. 24-1/2, N. 10.

"Empire" of past seasons is G. 18-1/2, B. 11, W. 16-1/2, N. 54, while "Neptune" of this season is G. 13-1/2, B. 2-1/2, W. 11, N. 73, both being broken blue greens.

"Topia," a beautiful brown, is O. 10, N. 90, a pure shade of orange, while "Bolide" is a lighter yellow orange with a nomenclature of O. 18-1/2, Y. 2-1/2, W. 1-1/2, N. 77-1/2.

We might analyze "Elephant's Breath," "Baby Blue," "Nile Green," "Crushed Strawberry" and others common in the market, but while the names will no doubt occur each season the colors will change with the fickle demands of the goddess of fashion and the interests of the manufacturers and dealers. In writing any color nomenclature the letters should be used in the following order: R.-O.-Y.-G.-B.-V.-W.-N., thus always listing the standard colors before the white or black. For example, never place Y. before O. or R., and never use N. before W. If this order is strictly adhered to the habit is soon acquired and a valuable point gained.

It has been shown that combined white and black disks form neutral gray, which is a white in shadow or under a low degree of illumination. If to such a gray a very small amount of color is added, as orange for example, by the introduction of an orange disk, this neutral gray becomes an orange gray, but unless the amount is considerable it can not be detected as an orange, but the gray may be termed a warm gray, denoting that it is affected by some one of the colors near the red end of the spectrum. If blue instead of orange is added to the neutral gray, a cool gray is produced. When green is added to a gray the result can not fairly be called either warm or cool, and hence we have termed it a green gray. According to this plan we have four classes of grays, Neutral, Warm, Cool and Green grays. As there may be many tones of each, and many intermediate combinations from red to green, or green to blue, the number of grays in nature is infinite, but these four classes with two tones of each in the papers form what may be called standards or stations from which to think of the grays, the same as the six standards in the spectrum constitute points from which to think of pure colors.

A careful consideration of the foregoing pages, accompanied with a color wheel or even a color top, can hardly fail to give a student who will make the experiments a clear idea of the use of the disks in the system of color education in which they form such an important feature, and therefore the old theory of three primaries, red, yellow and blue, and all that it leads to can be very intelligently considered and tested by them in the experiments which follow.

This old theory briefly restated is as follows: It is said "there are in nature three primary colors, red, yellow and blue; and by the mixture of these primary colors in pairs, orange, green and violet may be made." In fact leading educators have said that "in the solar spectrum, which is nature's chart of colors, the principal colors are red, orange, yellow, green, blue and violet; *of these* red, yellow and blue are primaries from which may be made the secondaries, orange, green and violet." All such statements as heretofore made in any popular treatment of the subject are understood to mean that in a pigmentary imitation of a spectrum the secondaries as enumerated may be produced by the mixtures of the primary pigments, because pigmentary mixtures are the only combinations generally recognized.

This theory has also included the statement that the primaries are complementary to the secondaries in pairs, and that the combination of the secondaries in pairs may produce a distinct class of colors called tertiaries.

It will be the aim of the following pages to demonstrate that in all this there is neither scientific or æsthetic truth nor educational value.

The Old Theories Tested by Mixture of Three Pigments.

Experiments in mixing the three pigments, red, yellow and blue, to produce the secondaries, orange, green and violet, have been very carefully made with interesting and instructive results. All such experiments are valueless unless made with one accepted set of primaries for the three combinations, because it is self-evident that if we select a vermilion red which is very decidedly an orange red, and choose for our yellow one of the orange yellows, the mixture will more nearly approach a true orange than if a standard red and standard yellow are used. Also in making a violet, if we mix a carmine, which is a violet red, with a decidedly violet blue, of which there are many, the result will be a better violet than the combination of the standard red and blue. So also in the mixing of blue and yellow to make green, a greenish yellow and a greenish blue will necessarily produce better results than the standards. Therefore, to test the matter fairly, the same pigments which are used to coat the standard red, yellow and blue papers have been combined so as to produce the best possible orange, green and violet, and these results when analyzed on the color wheel are as follows:—

The orange made by mixing standard red and yellow pigments in the best proportions is equal to O. 46, W. 2, N. 52. The violet is equal to V. 20, W. 1, N. 79, and the nearest approach to a standard green is shown by disk analysis to be G. 37, W. 7, N. 56, which is better than the violet and nearly as good as the orange.

These experiments show that heretofore when a line of standards of six colors has been prepared from three primaries, red, yellow and blue, even though the purest possible colors may have been selected for the primaries, the secondaries have not been in the same class of colors, and that all of them are very dark broken colors. Therefore, in using educational colored papers based on such a scheme, the pupil has received no correct impressions of the relative values of the several colors involved in pure spectrum scales, but has been shown at the outset a mixture of pure and broken colors *as standards*.

This is not a matter of opinion regarding best harmonies, because it is easy to demonstrate that less skill is required to combine broken colors harmoniously than pure colors, but it is a choice between truth and error in the early education of color perception.

Old Theories Tested by the Color Wheel or Color Top.

While it may be impossible for the reader to secure pigments exactly like the standards, red, yellow and blue, used in the above experiments, and therefore the statement here made can not be accurately verified, any one having a color wheel or even a color top may test the same combinations by use of disks. If it is true, as claimed, that a good standard orange can be made by mixing red and yellow, then it should follow that when a red and yellow disk are combined and a smaller orange disk placed in front of them, that it ought to be possible to so adjust the proportion of red to yellow that by rotation the outer ring of color will match the central orange disk.

A trial of this experiment will show that while the color resulting from the best possible combination of red and yellow is a kind of orange, it is not even an approximation to the standard orange, but is a shade of orange which may be matched by combining the smaller orange disk [Pg 47] with a black disk in the proportion of O. 45, N. 55, the larger disks being R. 89, Y. 11.

In combining red and blue disks to make a violet the result is more satisfactory, while if we attempt to produce a green by combining the yellow and blue disks the result will be surprising, but probably not convincing, because the statement that yellow and blue make green has been so persistently reiterated as a fundamental axiom that people who have given the subject but little attention will feel that to doubt it is rank heresy. In a text book treating of color is found the following passage: "Green substances reflect the green, i.e., the blue and yellow rays of the sunlight and absorb all the others." It is a fact, however, that in the mixture of blue and yellow light there is little or no trace of green, as a single experiment with a color top or color wheel will readily demonstrate.

In response to this convincing experiment a colorist of the "old school," (and there are few others) will doubtless say, "Such an assertion seems to be true when applied to these rotating disks, but we see no practical value in experiments of this kind, because in the use of color we must depend on pigmentary combinations, and in pigments yellow and blue do make green." The author of a statement of this kind is always honest in making it, and yet it is absolutely untrue, because as has already been shown, the green resulting from the mixture of yellow and blue can not be placed even approximately in the same class as the yellow and blue of which it is composed.

In accepting the disk combinations of standard pigmentary colors we are assuming a system of color investigation based on the combination of colored light rather than the mixture of pigments, and to an artist who has given the subject little thought this seems quite radical, not to say startling. But, logically, why is it not the most natural as well as the correct basis for this work?

Art in color must be based on the imitation of natural color effects. We must first learn to see [Pg 48] color correctly and to know what we see, and after that it is a very simple matter to learn which pigments to combine for producing any desired result which is already clearly defined in the mind. In fact the best selection of pigments must often be based on their chemical and mechanical qualities as much as on their peculiar hues.

All color impressions of material substances are produced by colored light reflected from a material surface to the retina of the eye, through which by some unknown means it is conveyed to the brain. When the white sunlight falls on a material substance a portion of the rays are absorbed and others are reflected to the eye, thereby conveying impressions of color. If on a surface of yellow material we throw a strong orange light through a colored glass, some of the orange rays from the glass will mingle with the yellow rays and the two are reflected to the eye, thereby producing an orange yellow or yellow orange effect where before it was yellow. So in a summer evening landscape when there is a so-called red sunset, everything is illuminated by an orange light and each color in the landscape is affected by the orange rays which mingle with the rays of the local color and are reflected to the eyes of the observer, producing the effect of local colors mixed with orange.

In a room where the windows open on to a green lawn with many trees in close proximity to the house, nearly all the light is reflected from green surfaces, and hence is green light. In such a case a correct painting of objects in that room would have a general green effect.

The afternoon light in a room on the west side of a city street may be nearly all red light, reflected from an opposite red brick wall, and such a room would be ill-adapted to showing fine dress goods, because the hues of the more delicate colors would be entirely changed, and hence would give a false impression as to the relations of the several colors in combination as seen in white or clear daylight. If a piece of light blue silk is illuminated by sunlight passing through a bit of yellow glass, no trace of green effect will be produced, but a gray either slightly yellow or blue, [Pg 49] according to the relative strength of the colors in the glass and the silk. This same effect would be secured if the yellow light of the setting sun illuminated the same material, but under such conditions everything else would be similarly affected so that the effect would not be so apparent.

The idea that all color is derived from the three primaries, red, yellow and blue, is so generally believed that our best writers among artists, colorists and educators have repeated it for many years. George Barnard, an English artist, in a very valuable book on water color painting, speaking of the colors of the spectrum which may be re-combined to form white light, says that if the yellow and blue rays are combined they produce green.

Chevreul also states in his invaluable book on color contrasts that yellow and blue threads woven into a texture, side by side, produce green. This statement is the more remarkable because the writer was a very careful investigator and is but another evidence of the strong hold which the Newton and Brewster theory has had on the public mind for so many years.

The story is told of an artist who wished to introduce into a composition of still life a blue vase with a bit of yellow lace thrown over a portion of it, and having been educated to believe that yellow and blue made green, gave a green effect to the portion of the vase covered by the lace. Had he known that blue and yellow light combined make gray instead of green he would have avoided the error.

The fact that gray is the product of blue and yellow light is sometimes taken advantage of in forming backgrounds in lithographic printing, in which a stippling of alternate dots of yellow and blue, very close together but not overlapping, is used to produce a beautifully transparent gray much more pleasing than any one tint of gray. This result is due to the blending of the two colors in the eye with the same effect as the colors of two rotating disks are mingled. The fact that there is a difference between the color effects produced by mixing two pigments and the mixing of the [Pg 50] light reflected from similar colored surfaces is a very strong argument for a system of color instruction based on disk combinations, rather than on pigmentary mixtures.

In order to obtain the most truthful effects of color in nature the artist should have sufficient knowledge of the principles which govern the combination of colors by reflected light, so that his reason may aid his eyes.

A little experimenting with the rotating disks and with pigments will convince any one that the disk combinations form the only possible basis at present known for logical color instruction.

Concerning the Complementary Colors.

Having shown that the three colors, red, yellow and blue, can not be combined to make an orange, a green or a violet of a corresponding degree of purity, we will consider the other claim which is set up by the advocates of the Brewster theory, namely, that the secondaries are complementary to the primaries in pairs, the green to the red, the violet to the yellow and the orange to the blue.

As all color is contained in white light, if we take from white light any given color, the color remaining is the complementary. If a small disk of standard red paper is placed on a white wall and the eyes fixed intently on it for a few seconds, and then the eyes slightly moved back and forth, a ring of a bluish green tint will be seen surrounding the red paper, or if the eyes are fixed intently on the disk for a short time and the paper suddenly removed, a disk of the same blue green tint will be seen in place of the red disk. This is called the accidental color and is supposed to be identical with the complementary color, although the image is too faint to give any very exact effect, but it is sufficient to furnish a clue to the complementary, and we may infer that a color between green and blue is that which is required.

Now if we can determine in what proportions red, blue and green must be united to produce [Pg 51] white light we may solve the problem. This is not possible in the use of any pigmentary colors, because of the impurity of all pigments as compared with spectrum colors. Although the mixture of colored light reflected from the disks, which are made of pigmentary colors, gives much purer color than the actual mechanical mixture of the two pigments, still, because it is a reflection of pigmentary colors, it is far lower in tone than the corresponding mixture of spectrum colors. Therefore it can not be a pure white, but may be white in shade or a neutral gray, which, as already shown, can be produced by the combination of a white and a black disk.

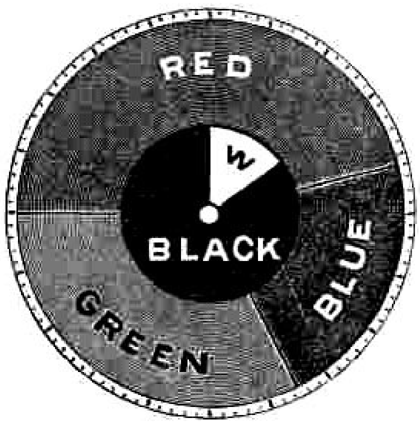


Fig. 12.

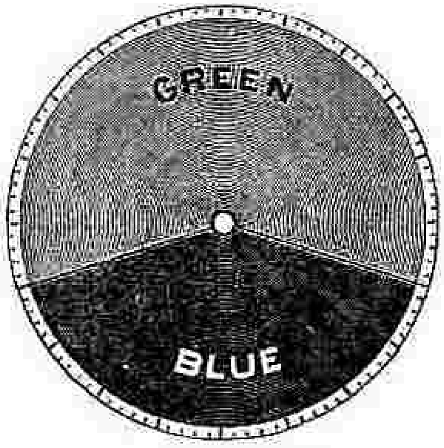


Fig. 13.

Therefore if red, blue and green disks of medium size are joined on the wheel and in front of them small white and black disks are combined, we have a means for solving this problem. If these various disks can be so adjusted that when rotated the effect of the three colored disks is a neutral gray, (or white under a low degree of illumination) exactly matching a gray that may be obtained by adjusting the small black and white disks, then one step in the solution is taken, as shown in Fig. 12.

With such an arrangement a very close match is produced, when the combined disks show the proportions to be R. 41-1/2, B. 22-1/2, G. 36 for the larger disks, and for the small disks W. 15, and N. 85. Now if blue and green are combined in the same proportions, as indicated above and in quantities sufficient when added together to fill the entire circle of 100 parts, blue will contain [Pg 52] 38.3 parts and green, 61.7 parts, as shown in Fig. 13, and the disks when rotated will give the color which is the complementary of red: namely, a blue green.

In the same way the complementary of each of the other standard colors, and in fact of any color, may be obtained.

The complementary of orange is another color between the green and blue, but more largely blue. The complementary of green is a violet red, and of violet a color between yellow and green, while yellow and blue are very nearly complementary to each other.

These figures furnish the results in a very well-lighted room, with a perfectly white interior. It is a well-established fact that this experiment is somewhat affected by the degrees of illumination, and also that colored light from the walls and ceiling of a room must of necessity have its effect, but all these matters are so insignificant as to be of no material consequence in the æsthetic study of the subject, and they can be very nearly eliminated when necessary by a careful selection of conditions. Whenever accurate experiments in pigmentary color comparisons are to be made, either by the use of rotating disks or otherwise, it is desirable to have a very well-lighted room, with a northern exposure and to select a morning or noonday light from a slightly overcast sky. These conditions obviate the unpleasant effect of direct sunlight in the room and also the very slightly blue effect of the clear sky. These precautions are unnecessary in experiments relating to the ordinary æsthetic consideration of color combinations, but even in such work it is important to exclude all light reflected from neighboring trees or colored buildings. Also the interior of the room should be as free from color as possible; a clean white surface is especially desirable.

A Chart of Complementary Colors, shown in Fig. 14, has been found very valuable in fixing in the minds of teacher and pupils the complementaries of the six standards. In this chart, which is [Pg 53] about eighteen inches in diameter, the circles at the ends of the six diameters are colored papers selected from the Bradley coated papers, as approximating the true complementaries. In the majority of cases they are not far from correct, but are least satisfactory in the blue and yellow. Theoretically the complementary of the ideal standard blue is a slightly orange yellow, and of the standard yellow a slightly violet blue. But there is as yet no blue pigment in the market suitable for commercial use which is free from a slightly violet effect. Therefore the standard blue paper is practically as good a complementary for the standard yellow as the violet blue paper. But notwithstanding these slight imperfections which are at present unavoidable, the chart is a valuable aid in fixing in the mind the positions of the complementary pairs in the spectrum circuit.

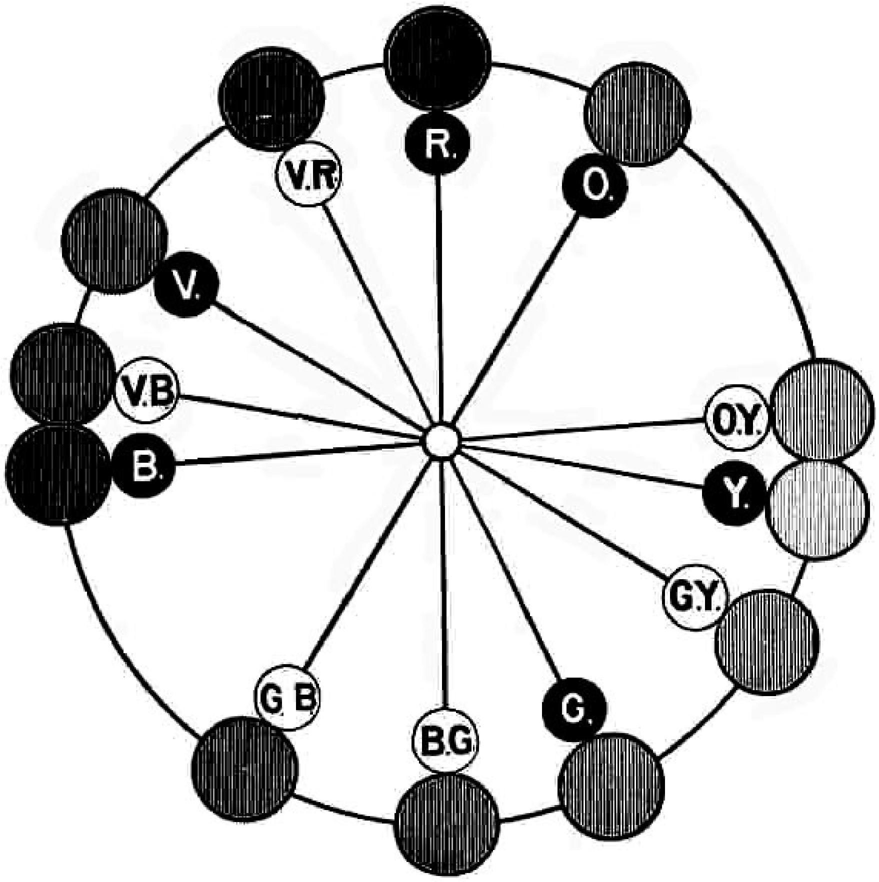


Fig. 14.

Each of the foregoing experiments furnishes an interesting class exercise, and may be very closely repeated by the pupils with their tops. Also the computation of the proportion of green and blue when raised to the full circle may form a practical problem in proportion for pupils of the higher grades. Taken together, these experiments prove that the complementaries of the old primaries are not found in the secondaries. [Pg 54]

The last claim of the Brewster theory is that the secondaries by combination form three lines of colors peculiar to themselves, called citrines, russets and olives. It is asserted that the mixture of orange and green makes citrine; orange and violet russet; green and violet olive. Although these names may be very convenient terms to express three general classes of colors, they must of necessity be too general and indefinite to be of value for accurate expression of color effects, and are in fact so vague that hardly two persons can be found in a large company who will agree as to the best expression of either of them. The following are formulas for a number of colors in each class, as made from analyses of colors coming under these names. It is an interesting exercise to produce some of these colors by means of the rotating color disks and test the opinions of the different members of a company as to which best represents to each one of them a tertiary color, as citrine, for example. For this purpose three different formulas may be shown at the same time, with three sizes of disks.

Citrines.

O. 7.	Y .13.	W. 3½.	N. 76½.	
	Y. 15.	W. 4.	N. 81.	
	Y. 13.	W. 5.	N. 76.	G. 6.
O. 6.	Y. 20.	W. 4.	N. 70.	
O. 3.	Y. 6.	W. 8.	N. 83.	

Russets.

R. 37.	O. 8.	W. 8.	N. 47
R. 79.		W. 10½.	N. 10½.
R. 33.	O. 20.	W. 6.	N. 41.
R. 36.	O. 4.	W. 9.	N. 51.
R. 47.	O. 7.	W. 8.	N. 38.

[Pg 55]

Olives.

G. 19.	B. 11½.	W. 10½.	N. 59.
G. 13.	B. 6.	W. 12.	N. 69.
G. 14.	B. 12.	W. 8.	N. 66.
D. 10½.	B. 15.	W. 8.	N. 66½.
G. 12½.	B. 5½.	W. 4.	N. 78.

The term citrine theoretically covers all possible combinations of orange and green, but as generally understood those colors which are so near the orange or the green as to very decidedly approach either the one or the other are not included, and, as shown in the above analyses, a citrine is a very broken color ranging from an orange yellow through yellow to a green yellow.

Although the russets would theoretically range from violet to orange, yet the general conception of russet will hardly accept a violet red, but will cover only the red and orange reds as above indicated, while olives are confined to blue greens and green blues.

These tests are based on combinations of the Bradley standard orange, green and violet pigments, and therefore are far stronger in color than those colors usually termed citrine, russet and olive, made by mixing the pigmentary secondaries. For example, if a yellow and blue pigment are mixed to form a green, and red and yellow pigments to make an orange, and then this green and orange are mixed to produce a citrine, the result will be very much darker and more broken than the mixture of the purer orange and green colors used as standards.

Restricted to these limits these names may become very useful terms for general color expressions, as covering three different classes of broken colors. If any one believes that these color formulas do not correctly represent the three classes of colors indicated, a series of experiments with even the small color top will prove very convincing.

When the subject of standards as a means for identifying colors is mentioned artists frequently express the feeling that the names of pigments are good enough for them, such as Ultramarine Blue, Prussian Blue, Vermilions, the Siennas, Indian Red, etc. The following are the analyses of several samples of Vermilion, Burnt Sienna, Raw Sienna, and Indian Red of the best tube oil colors in the market:—

Vermilion.

R. 80.	O. 14.	W. 6.
R. 87.	O. 8.	W. 5.
R. 50.	O. 24.	W. 26.

Burnt Sienna.

R. 1¼.	O. 6.	W. 3.	N. 89½.
R. 22½.	O. 11½.	W. 2.	N. 64.
R. 25.	O. 12½.	W. 5½.	N. 57.

Raw Sienna.

O. 18½.	Y. 6½.		N. 75.
O. 17.	Y. 14.	W. 1.	N. 68.
R. 8½.	Y. 3½.	W. 2.	N. 86.

Indian Red.

R. 11½.	O. 7.	W. 4.	N. 77½.
R. 13½.	O. 13½.	W. 2½.	N. 70½.

A careful examination of these formulas and a reproduction and comparison of the colors on the color top will convince any one that in no case does the commercial name determine the color with a degree of accuracy sufficient for any valuable nomenclature.

Classification of Harmonies.

The theory of the harmonies of colors is a subject which awaits very careful investigation and a general discussion by artists and expert colorists. Such investigations must include many experiments based on common standards and uniform methods of measurements and records.

Harmonies naturally seem to fall into a few general classes which are convenient for comparison and discussion as well as for elementary instruction, but no one person can set himself or herself up to decide which are the *best* harmonies. The practices and recommendations of noted artists who have appeared to be gifted with intuitive perceptions regarding color combinations have frequently included those for which there seemed to be no recognized authority, and yet their beauty could not be questioned. As the rules of grammar are but the correlation of the practices of the best scholars, so the rules governing color combinations must be the summary of the practices and recommendations of the best artists, if they are to be generally accepted as final, and hence we must patiently await the growth of similarly established laws by the comparison of the opinions of critics of acknowledged ability in various departments of the world of art. This has not been possible in the past and can never occur until there is a language of color through which color facts can be somewhat accurately expressed in verbal and written language, and this language cannot exist until there is an accepted alphabet of color on which it can be based. This alphabet is now in part furnished by the spectrum standards and completed by the pigmentary standards and the rotating disks made like them. Together they form the basis for a nomenclature by the use of which the questions involved in harmonies can be discussed and the results expressed in written language.

In the investigation of any subject with a view to elementary instruction, classification is an important factor, but one which heretofore has been almost ignored as regards color education. Consequently at present the more definite division of harmonies into classes is very much a matter of personal opinion, but Mr. Henry T. Bailey, State Supervisor of Drawing in Massachusetts, has suggested a very useful classification in which he arranges all harmonies under these five heads: Contrasted, Dominant, Complementary, Analogous and Perfected.

Contrasted.—The contrasted harmonies are those in which color is contrasted with non-color, or more accurately in which an active color, that is a tone from the spectrum circuit, is contrasted with a passive color, white, black, gray or silver and gold; for example, a blue green tint with white, or green blue with warm gray No. 1. [Pg 58]

Dominant.—By dominant harmonies we mean those in which are combined different tones from one color scale. For example, red tint No. 1, and red shade No. 1, or a green blue tint, green blue, and a green blue shade. A dominant harmony composed of grays, or white, gray and black, is sometimes called a neutral harmony.

Complementary.—This term refers to those harmonies in which are combined opposite or complementary colors in the spectrum circuit. The best of them show not only opposition in color but also opposition in tone. Thus, tints of one color with shades of its complementary produce a more pleasing effect than do complementaries of equal value. The best complementary harmonies contain one or more passive colors.

Analogous.—This name is applied to those harmonies in which are combined tones from scales of neighboring colors in the spectrum circuit.

For example, in a composition of colors from that part of the spectrum containing yellow, green yellow and yellow green the following simple combination may be made: Yellow tint No. 1, green yellow and yellow green shade No. 2.

Perfected.—By perfected harmonies we mean those in which the general effect of one analogous harmony is complementary to that of another.

The above classification of harmonies is very valuable for fixing in the mind the various effects of color combinations, and yet they may seem to somewhat merge into each other in their application, until the underlying principles which govern them are understood. It is unwise to suppose that because the above classification of harmonies is based on the science of color we can infer that it furnishes definite rules for producing best effects.

The Work of Chevreul Reviewed.

The good or bad effect of two or more colors in combination in decorative designs or fine art depends very largely upon phenomena which are elaborately explained in a book entitled "The principles of Harmony and Contrasts of Colours" by M. Chevreul. [A] The first edition of this book was prepared in 1835 and published in 1838. The author had at that time been employed for a number of years as superintendent of the manufactory of Gobelin Tapestries in Paris under the control of the French government. [Pg 59]

In this book are described in detail the results of a great number of experiments which were instigated by complaints regarding certain colors produced in the dyeing department of the manufactory, and which afford the most elaborate exposition of the subject ever published.

One of the first things which led Chevreul to make his investigation was the complaint that certain black yarns used as shades in blue draperies were not a full black but more or less gray.

The author says in his preface, "The work I now publish is the result of my researches on Simultaneous Contrasts of Colours; researches which have been greatly extended since the lectures I gave on this subject at the institute on the 7th April, 1828. In reflecting on the relations these facts have together, in seeking the principle of which they are the consequence, I have been led to the discovery of the one which I have named the *Law of Simultaneous Contrast of Colours*."

The closing sentence of the preface to the first edition and dated 1835 is as follows:—

"I beg the reader never to forget when it is asserted of the phenomena of simultaneous contrast, *that one colour placed beside another receives such a modification from it*, that this manner of speaking does not mean that two colours, or rather the two material objects that present them to us, have a mutual action, either physical or chemical; it is really only applied to the modification that takes place before us when we perceive the simultaneous impression of these two colours." [Pg 60]

It was not till three years later that a publisher could be found for this book, which is still a standard.

The English translation comprises over five hundred closely printed pages with many engraved and colored plates, and yet, it has been of comparatively little value in *popular instruction* because of the lack of a generally accepted color nomenclature or list of well defined color terms, by which the readers might have understood and repeated for themselves the experiments described.

Unfortunately Chevreul was fully impressed with the Newton-Brewster idea of three primaries, red, yellow and blue, and therefore some of his deductions from his experiments seem to have been more or less influenced by the attempt to make them harmonize with this theory, and yet the subject which he has treated so exhaustively and intelligently is one of the most important in the æsthetic study and use of colors. In all expressions of colors in combination with each other, whether in nature, fine arts or the decorative and industrial arts, every color is affected by its surrounding colors, a fact which is exhaustively treated in this book.

While with our present knowledge of the subject it does not seem that the material use of color can be reduced to an exact science, this should not prevent us from accepting all the natural and scientific aids which have been or may be discovered toward this desirable result. Because of this lack of scientific knowledge in Chevreul's time much of the worth of his experiments is lost to us, yet there is very much of value in his work, suggesting as it does experiments which may be tried with present standards and modern methods.

If the use of Maxwell disks had been known to Chevreul his deductions from his experiments would have been quite different in their details. For example, in accepting the proposition that [Pg 61] there are three primaries, red, yellow and blue, which may be combined in pairs to make the secondaries, orange, green and violet, he states that owing to the impurities of the pigments the secondaries are not as pure as the primaries. Consequently he believes that this may account for many of the shortcomings which he was too observing to overlook; but notwithstanding such an error in theory this wonderful investigator made many practical experiments and established very valuable facts regarding color contrasts.

The term Simultaneous Contrast seems rather restricted for a title covering such a range of effects, and the author subdivides the subject into simultaneous contrasts, successive contrasts and mixed contrasts, which he defines as follows:—

Simultaneous Contrast.

"In the Simultaneous Contrast of Colors is included all the phenomena of modification which differently colored objects appear to undergo in their physical composition and in the height of tone of their respective colors, when seen simultaneously."

Successive Contrast.

"The Successive Contrast of Colors includes all the phenomena which are observed when the eyes, having looked at one or more colored objects for a certain length of time, perceive, upon turning them away, images of these objects having a color complementary to that which belongs to each of them."

Mixed Contrast.

"The distinction of Simultaneous and Successive Contrast renders it easy to comprehend a phenomenon which we may call the mixed contrast; because it results from the fact that the eye, having seen for a time a certain color, acquires an aptitude to see for another period the complementary of that color, and also a new color, presented to it by an exterior object; the sensation then perceived is that which results from this new color and the complementary of the first." These last two effects may be shown very clearly in simple experiments.

There are various phenomena which may be classed as successive contrasts sometimes called [Pg 62] "after images." The phenomena which Chevreul groups under the term "Simultaneous Contrast of Colors" belong to a class of physio-psychological effects termed after images, and more definitely to the subdivision called negative images. The positive after images are not important in the consideration of the theories of color and therefore are not described here. The specific effect most directly involved in the subject of harmonies may be observed if the eyes are fixed upon a small disk of red paper on a white wall for a few seconds and then the paper is suddenly removed, as there will appear on the wall in place of the full red disk a faint tint of a blue green. This is called an after image, and is nearly or exactly a tint of the color complementary to red.

For making this experiment mount a circle of red paper, say three inches in diameter on a square white card, four or five inches across, and grasping the card by one corner hold it in front of a white wall or a sheet of white paper pinned on any support. Tell the observer to look intently at the red disk for a half minute, and then without giving any notice suddenly remove it and ask what color is seen in place of it. At the first trial the result may not be entirely successful, because the eyes of the observer may naturally follow the red spot when it is removed instead of remaining fixed in the original position, but a second trial will bring the expected result. To illustrate mixed contrast, fasten on the wall a piece of red tint No. 2 paper four or five inches square. This may be very conveniently done by using a bit of beeswax on each corner of the paper, which will not soil the wall. Then having the three-inch circle of standard red paper mounted on a white card somewhat larger than five inches square hold the card in front of the red tint on the wall and repeat the experiment as before. The effect now should be a three-inch disk of very light gray in the center of the pink square, which is a "mixed contrast" according to Chevreul. The reason is simple. The after-image or successive contrast of light blue-green is [Pg 63] projected on the red tint and being complementary the resulting effect is a gray. If the red tint could be exactly graded to the complementary effect in the eye the resulting gray circle would be a true neutral gray. Another illustration of the same physical effect by which the complementary is induced may be shown by substituting for the tint of red a light tint of the blue-green paper retaining the full red disk as before. The same blue-green after image is now projected on to the light blue-green paper and hence a circle of more intense blue-green is produced. Thus it is seen that Chevreul's successive and mixed contrasts are both due to the same physiological effect, the only difference being in the ground on to which the after image is projected.

It probably is unnecessary to state that these experiments may be made with any color and its complementary and that red and blue-green are used here merely as an example.

Another phase of the same physical effect is seen under other conditions which may at first seem to be quite different from those described, but which on examination appear somewhat similar.

It is a well established fact that when two surfaces approximating each other in color, as red and orange for example, are placed side by side, both are rendered less brilliant, an effect which might be reasonably expected because in order to see both the eye is naturally directed first to one and then to the other, and in each case the after image induced is a green-blue or blue-green, which being approximately complementary to both, dulls both. Or in other words, it is as though one examines for a long time a line of goods of similar colors so that the eye becomes fatigued and the color dulled. It is said that a good salesman of colored materials will endeavor to occasionally attract a customer's attention for a few moments to some other colors approximating a complementary, so that when the attention is again directed to the goods under consideration the full effect of the color may be secured.

If it is true that the phenomenon of the after image is the cause of the peculiar effects expressed [Pg 64] by the terms simultaneous, successive and mixed contrasts, and that by these effects all harmonies in color are governed, it is certainly profitable to understand them while using color material with the children, for their good as well as our own pleasure.

Contrasted Harmony.

Returning to our classification of harmonies, already stated, we find the first to be Contrasted Harmony, which covers those combinations in which a positive color, as a spectrum color for example, is combined with white, black or gray, leaving out for the present silver and gold, which may be confusing, and can at best be used only as outlines.

The simplest combinations of colors are found in this class, all of which are not equally harmonious, and some may not perhaps be entitled to be classed as harmonies, although not positively inharmonious. In this class, as in all others, there is involved contrast of tone and contrast of color, which may best be considered in several divisions.

Color with White.

According to the results of Chevreul's elaborate experiments the effect of a combination of an active color with white is to render the color more brilliant and to give to the white the effect of the complementary of the active color. He admits that the modification of white is very indefinite, but claims that, knowing what to expect, a complementary effect may be seen which otherwise would not be noticed. There is also a contrast of tone which in all cases tends to strengthen a color when used with white.

Black with White.

White and black are both intensified by combination with each other, and this is the type of "contrast of tone." Contrast of tone is very clearly shown when two or more grays of different tones are placed contiguous to each other. This experiment is easily tried by mounting side by side several strips of gray papers of different tones. If more than two are used they should be [Pg 65] arranged in order from lightest to darkest. In this case each band will appear to be graded in tone from one edge to the other, each being lighter at the edge next to the darker paper.

This effect is plainly shown on the color wheel by producing several rings of grays with white and black disks of several sizes graduated from light at the center to darker at the circumference.

Color with Black.

In consequence of this law of contrast of tone the contrast of black with active colors generally tends to intensify the black and lower the tone of the color, i.e., to weaken it as though white or light gray was mixed with it, but this effect is modified by contrast of color. Contrast of color is perceptible in black when combined with color simply because the black is not perfectly black but a very dark gray, and hence there is the same complementary effect which shows in white and the lighter grays, but in a smaller degree. This effect is most clearly seen when the color used in combination is blue or blue-green, which induces in the black, yellow or red complementaries and gives the black a "rusty" appearance.

On the other hand, for example, red with black adds the complementary green-blue to the black, which improves it. The orange and yellow have a similar effect by their blue complementaries to relieve the black from any rusty appearance and a green yellow induces a violet effect in the black.

Colors with Gray.

When a color is contrasted with white the light from the pure white surface is so intense as to very largely obscure the complementary effect on the white, while on the other hand the feeble light from the black is not favorable for the exhibition of a complementary. So it might naturally be inferred that some tone between the white and black would be much more favorable than either for the observance of this effect, which is proved by experiment to be the case. This fact is [Pg 66] illustrated in the familiar experiment of placing a white tissue paper over black letters on a colored ground, by which the black is practically rendered a neutral gray and the color a light broken color, and in appearance the gray letters receive a color complementary to the color of the page on which they are printed. Each color has its own tone of gray most susceptible to this complementary effect. The truth of this proposition can be perfectly shown on the color wheel by forming with three different sizes of disks a gray ring on a colored surface. For example, select small disks of orange and white of equal size, then a black and a white disk of the second size and an orange and a white disk of the third size. First place the large orange and white disks on the spindle, then join the two medium-sized white and black disks and put them in front of it, and lastly add the small orange and white disks. By rotation the result is the required neutral gray ring on a light orange surface. By the joining of the white disk with each of the orange disks the orange surface may be changed to a variety of tints for trial with the different grays which may be made from the black and white disks, so that the best tones of both orange and gray may be secured. When the best proportions are obtained the effect will be surprising, because when such disks are properly adjusted the complementary effect is so strong in the gray that it appears as a very definite color, a broken green-blue. It is said that the tone of gray should have the same relation to the tone of the color that its complementary would have in order to get best results.

For the same reason if a circle of lightest neutral gray paper, say four inches in diameter, is placed on a piece of yellow paper about six inches square, and another circle just like it is put on a piece of blue paper of similar size, it will be quite difficult to convince any one who has not previously seen the experiment that both gray circles are from the same sheet of paper. The results observed in this experiment are produced by a contrast of tone which causes one to look [Pg 67] lighter than the other, and a contrast of hue which gives one a blue and to the other a yellow hue, in contrast to the color on which it is mounted.

Contrast of Colors.

If two colors contiguous in the spectrum circuit are placed in juxtaposition the effect of the contrast of hue is to throw them away from each other. For example, if orange red and the red orange papers are put side by side the former will seem more red and the latter more orange. Therefore, when colored papers are pasted up or laid in order to form a spectrum, for example, the colors not only fail to blend together but each line of contact is very disagreeably prominent.

If two colors are separated by a narrow strip of light gray, gold, black or white, the effect is greatly improved. For this reason a design in analogous colors is often improved by separating certain colors by a fine line of black, gold or gray.

If two colors not closely related to each other in the spectrum circuit are placed in juxtaposition, each is modified by an effect which is the complementary of the other. For example, if red and yellow are placed side by side, in contact, the red is rendered more violet by the added effect of blue, which is the complementary of yellow, and the yellow is modified by the blue-green complementary of the red, which tends to dull the yellow and change it slightly toward green.

If blue and yellow are joined both are improved, as the two are so nearly complementary to each other that each is intensified by simultaneous contrast, blue being added to blue and yellow to yellow.

Dominant Harmonies.

In the use of colored papers those combinations classified as dominant harmonies are the most simple to make because they are all in one family, as the little children like to consider the relationship. The red family consists of the standard red and its tints and shades, or in other words the red scale. With the several papers ready made this harmony becomes very simple, but [Pg 68] in the use of pigments the production of a true color scale is not a thing to be confidently undertaken by a novice.

In a very elaborate color chart for Primary education prepared with great care by Dr. Hugo Magnus and Prof. B. Joy Jeffries, and published at large expense about ten years ago with hand-painted samples in oil colors, this lack of classification of hues is very noticeable, although at that time it was by far the best publication of the kind and was not criticised on this point.

For example in a scale of five tones of red the following are the analyses, beginning at the lightest tint:—

Tint No. 2,	O.45,	Y.20,	W.18,	N.17.
Tint No. 1,	O.69,	Y.3,	W.7,	N.21.
Standard,	R.75,	O.25.		
Shade No. 1,	R.85,	O.15.		
Shade No. 2,	R.75,	N.25.		

In this scale according to the Bradley nomenclature the standard or full color is a very fine vermilion expressed by R.75, O.25, i.e. an orange red, and therefore in order to form a perfect scale both tints and shades should be in the orange reds, but in fact the tints are both broken colors, the lightest a very broken yellow-orange and the deeper tint very nearly a light broken orange. The lightest shade is a pure orange-red but with a larger proportion of red to the orange than the standard, while the darkest tone is a pure shade of red. Thus in the five tones we have the following arrangement, beginning at the lightest tint:—

Broken yellow-orange, broken orange, orange-red; another pure orange-red but more red, and lastly red shade, thus embracing in one orange-red scale parts of four scales from yellow-orange to red. In these defects in the best chart of its kind in the market only ten years ago is seen the best possible evidence of the advance made since that time in color perception, largely due to the use of the color disks in determining scales. While in the use of colored papers the dominant [Pg 69] harmony may be the simplest and the one in which there is least danger of really bad work, some of the combinations are much better than others, and superiority is perhaps secured as much by the relative quantities of each tone used in a composition as in the selecting of the tones. In the entire range of the spectrum even this class of harmonies involves problems too complex to be solved by a few rules, but it is a very interesting field in which the children may safely be allowed to roam and experiment.

Complementary Harmonies.

Complementary Harmonies may perhaps be classified next to dominant because they are more easily described and more definitely limited than those effects termed Analogous Harmonies. A pure Complementary Harmony consists of the combination of tones from two scales which are complementary to each other. For example, the red scale is complementary to the blue-green scale, as also the green to the violet-red, and so on throughout the entire range of the spectrum scales.

As explained on Page 50, the complementary of any color can be determined by means of the color wheel, or nearly enough for æsthetic purposes with the color top. But even though the colors complementary to each other may be determined scientifically there will always remain ample opportunity for the exhibition of color sense and artistic feeling in the choice of colors because the difference between a very beautiful composition in complementary harmony and an indifferently good one may be found in the choice of tones, or in the proportions of each and their arrangement with relation to each other. This harmony certainly contains great possibilities with comparatively few limitations.

While it is perhaps approximately true that complementaries are harmonious in combination, yet best authorities do not seem to fully sustain this opinion and it is quite evident that pure tones of some complementary pairs when combined are very hard in their effects, if not positively unpleasant. This can be relieved very decidedly and oftentimes very pleasing results secured by [Pg 70] modifying the colors to tints and shades or various broken tones.

But as has before been stated, and must be constantly reiterated, all fine questions of harmonies can only be determined by a general agreement of experts in color based on accepted standards.

Analogous Harmonies may seem to be more closely related to the dominant than the complementary and hence, logically, should perhaps be considered before the complementary, but there may be greater difficulties involved in the analogous than in the complementary because they are not so definitely limited.

Analogous Harmonies.

In an Analogous Harmony we may use tones from a number of scales more or less closely related in the spectrum circuit. In some parts of the spectrum it is possible to include a much wider range than in others. It is comparatively easy to produce safe compositions through that part bounded by the orange-yellow and the green scales, while from the green to the violet experiments are much less safe.

In almost any section of the spectrum a range of three scales is safe if the tones are properly selected and proportioned, and in some sections as many as five or six may possibly be included, by an artist, with striking and pleasing effect.

Perfected Harmonies.

The compositions which have been classified as Perfected Harmonies may be defined as the combination of two Analogous Harmonies which as a whole are approximately complementary to each other, or in which the key tones of the Analogous Harmonies are complementary to each other. Such compositions may be entirely composed of analogous colors with the addition of but one complementary color, and this is in fact a very safe harmony, especially if that one color is used as a border line or an outline here and there in the design, in which case it may sometimes be strong in color and tone.

The chart of spectrum scales as made from colored papers cut in squares is of great value in [Pg 71]
explaining the classification of harmonies. Fig. 15 is a reduced copy of the chart of pure spectrum scales shown on page 41, and which is here placed horizontally for convenience.

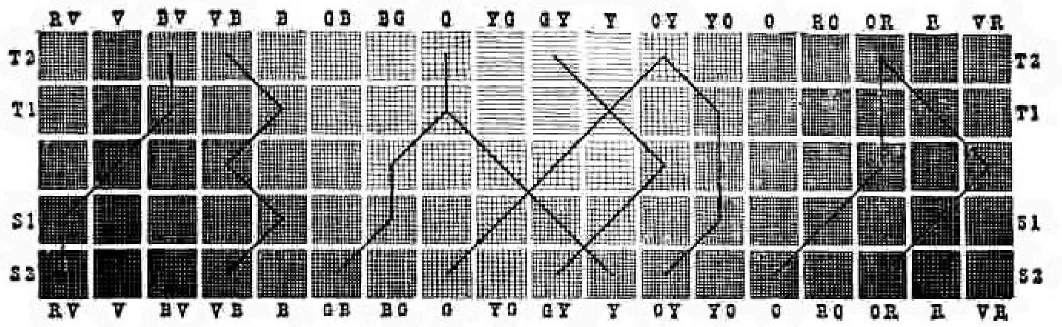


Fig. 15.

The black zig-zag lines are designed as graphic illustrations of the various classes of harmonies.

Contrasted Harmonies as defined are limited to designs in one active color mounted on a background of one of the passive colors and thus need no further explanation, although experience will prove that some combinations are very much more pleasing than others.

The Dominant Harmonies which are defined as combinations of tones from one scale cannot be made more clear by a diagram, which would be simply a straight vertical line through any one of the eighteen scales, indicating that the five tones in that scale or any selection from them may be used in a Dominant Harmony.

The Analogous Harmony has given students the most trouble and the diagram is principally prepared to illustrate the great variety in harmonies of this class.

Commencing at the left, the first line indicates a harmony in three scales beginning with red-violet shade No. 2 and passing to shade No. 1, then to standard violet and thence to blue-violet tints No. 1 and No. 2.

The next is in two scales, beginning at violet-blue shade No. 2, thence to blue shade No. 1; back to normal violet-blue; again into the blue scale at tint No. 1 and back to violet-blue tint No. 2. [Pg 72]

The next begins at green-blue shade No. 2 and ends in green tint No. 2. Theoretically the line beginning in G. B. S. 2. and leading to G. T. 1. and thence to Y. S. 2. may represent an Analogous Harmony, but it may be doubtful whether a range of such an extent in that part of the spectrum could be made very harmonious. This may be divided into two harmonies at G. T. 1. and each part may be extended to G. T. 2.

The straight line from G. S. 2. to O. Y. T. 2., embracing five scales, might be extended to include the joining broken line running into the Y. O. scale and finishing at O. Y. S. 2.

The remaining lines at the red end of the chart may be considered as indicating one harmony in six tones, or two harmonies in three tones each.

If the two ends of the Chart of Spectrum Scales are joined so as to form an endless band or a cylinder, bringing the violet-red scale adjoining the red-violet, as in the spectrum circuit, the same graphic illustration could be given of harmonies extending from violet to red.

The complementary harmonies require no diagrams, because they are limited to the combination of two scales complementary to each other and would be represented by two parallel vertical lines through any two complementary colors, as for example vertical lines through the red and green-blue scales.

The compositions termed Perfected Harmonies may be fairly well illustrated in the diagram by the combination of the line in V. B. and B. with the broken line commencing in G. Y. S. 2. and ending in G. Y. T. 2.; or again by the line in R. V. to B. V. combined with the straight line from G. T. 1. to Y. S. 2.; or the broken line G. to Y. S. 2. Or again, the entire range of the double combination O. S. 2., O. R. T. 2., V. R. and O. R. S. 2. with the broken line from G. B. S. 2. to G. T. 2. Another sample of Perfected Harmony is found in the union of line O. R. S. 2., V. R., O. R. T. 2., with line G. B. S. 2. to G. T. 2. These diagrams are designed to show the range or extent which a single composition may cover under its special definition and do not imply a necessity for using at one time all the colors through which the line passes, or that they are specially good harmonies. [Pg 73]

A striking illustration in nature of a Perfected Harmony was seen one bright autumn morning in a species of woodbine covering the side of a red brick building, in which could be discovered an infinite variety of colors in greens and violet-reds whose tones were increased in number and intensified in effect by the reflections of the sunlight and the corresponding shadows, producing very light tints and very dark shades of various hues of the complementary colors, and forming a complicated and wonderfully beautiful effect very definitely classified as a Perfected Harmony.

Field's Chromatic Equivalents.

So much has been said and written about Field's Equivalents that there is a very general impression among artists and others that they constitute an important element in harmonious compositions of color. This proposition as given in Owen Jones' Grammar of Ornament is as follows:—

"The primaries of equal intensities will harmonize or neutralize each other, in the proportions of 3 yellow, 5 red and 8 blue—integrally as 16.

The secondaries in the proportions of 8 orange, 13 purple, 11 green—integrally as 32.

The tertiaries, citrine (compound of orange and green), 19; russet (orange and purple), 21; olive (green and purple), 24—integrally as 64."

In commenting on this in "The Theory of Color" Dr. Von Bezold says: "It is often maintained that the individual colors in a colored ornament should be so chosen, both as regards hues and the areas assigned to them, that the resulting mixture, as well as the total impression produced when such ornaments are looked at from a considerable distance, should be a neutral gray. Starting from this idea, the attempt has been made to fix the proportional size of the areas, which would have to be assigned to the various colors usually employed in the arts, for the purpose of arriving at the result indicated. This idea was especially elaborated by Field, an Englishman, who gave the name of 'chromatic equivalents' to the numbers of the proportions obtained, a designation which has since been very generally adopted. In reality, however, these 'chromatic equivalents' have no value whatever." [Pg 74]

The same writer also says: "It will always remain incomprehensible that even a man like Owen Jones in the text accompanying his beautiful "Grammar of Ornament" should have adopted this proposition in the form given to it by Field, since among all the ornaments reproduced in the work just mentioned there are scarcely any which will really show the distribution of colors demanded by the proposition in question." [B]

In accordance with this eminent authority any one familiar with disk combinations will know by experiment that no combinations of red, yellow and blue approaching the proportion named by Field can produce a neutral gray effect in the eye.

Colored Papers.

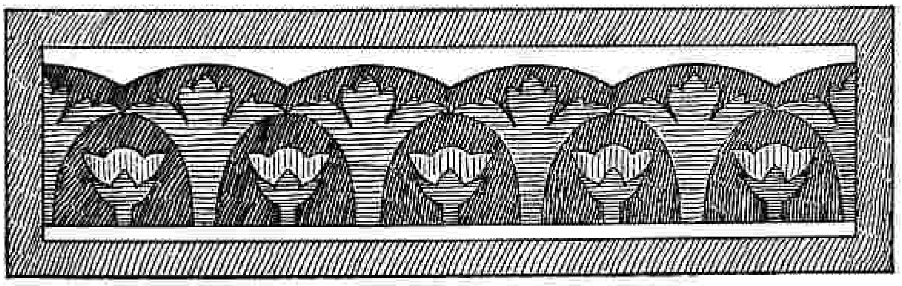
For practical study of color some economic material is absolutely necessary and nothing so well combines manual work with æsthetic cultivation as colored papers, if specially prepared in standard colors and with a dead plated surface.

In the manufacture of the colored papers adopted in the Bradley scheme of color instruction, the effort has constantly been to produce the closest possible imitations of natural colors consistent with the material.

With this aim in view we have secured the brightest possible red, orange, yellow, green and blue and have chosen a violet which has the same relation to the other pigmentary colors that the soft beauty of the spectrum violet bears to the other parts of the spectrum. [Pg 75]

It however happens that in the pure aniline colors discovered in recent years a line of purples and violets has been found so much purer than the other pigments that we cannot with our red and violet make a perfect imitation of the brightest aniline purples used in some of the goods now in the market. Purple is a general name for the several modifications of violet, red-violet and violet-red as Peacock Blue is a name given to the beautiful hues of blue-green and green-blue. These aniline purples are but another indication that we may expect such advance in the science of pigment manufacture in the comparatively near future that a much purer line of standards may be secured than is now possible in papers. But it does not materially affect the value of the present standards as long as they are accepted as indicating the kind of color, i.e., its location in the spectrum, and the *artists* certainly should not object to this lack of purity, because their only present criticism is that the standards are too "raw," which is but another term for pure.

In the glazed colored papers in the market we may find some of these purples, especially in the tints or "pinks" which when placed beside the unglazed surfaces of the standard papers render the latter quite subdued. But in primary color education there is no place for these purest purple papers, until chemistry discovers other colors correspondingly brilliant to complete a purer chart of spectrum colors than is now possible.



[Pg 76]

Color Teaching in The Schoolroom.

In the preceding sections of this book the author has aimed to so guide the teacher who is looking for aids in elementary color teaching that she can by actual experiment determine for herself the truths regarding color, and hence be able to choose such facts as are suited to the needs of her pupils from time to time, and to present them in such a logical order as to render them of the greatest value in practical results.

It should be possible to interest the children in color more easily than in any other subject. Examples are always around them at home, in the street, in the garden and the field, if perchance they are fortunate enough to see the field, and those who see no attractive colors elsewhere certainly should find them in the schoolroom. To a teacher who is in love with the subject the world will be full of examples, every day. The beautiful yellows and greens of the spring leaves, the flowers, birds and butterflies of the summer, the autumn foliage, the sunsets and blue and purple mountains of winter, are but hints of the multitude of object lessons in color all around us; and if none of these are available the more commonplace subjects found in the latest seasonable colors of dress goods and house furnishings will be almost equally valuable. When the children are once interested they will discover, through their own observation, examples of such value as to surprise one who has had experience with only the old methods of trying to teach color, or rather the utter lack of all methods heretofore in vogue.

The value of kindergarten training has been so thoroughly demonstrated as to be beyond controversy, and all progressive school boards must soon recognize the necessity of adopting kindergarten methods in the lower primary grades, until such time as it may be possible to introduce the complete kindergarten for all the children, to precede the school proper. The [Pg 77] conditions prevailing in the kindergarten are peculiarly favorable to the study of color, because of the opportunities afforded for introducing it in connection with the manual exercises of the gifts and occupations.

The first gift of the kindergarten, as originally introduced by Frœbel, consists of six soft worsted balls in six colors, which he seems to have selected as standards without care or knowledge regarding the theory of "three primaries and three secondaries," although no doubt he may have indifferently accepted it, because it was the only one in his day suggesting any logical scheme of color combinations.

The use of colored papers educationally in a systematic way originated in the kindergarten, and comprised folding, cutting, pasting and weaving, from which some color instruction was incidentally derived by the children. But with the papers formerly in the market little special training in the selecting, matching and naming of colors, such as is of so great value at the present time, was possible. The call for better colors in papers came first from the kindergartners, and the diversity of ideas expressed by them caused the writer to institute a series of investigations which have resulted in the system to which this book is devoted. The occupations of paper folding, cutting and pasting have been adopted into the primary school from the kindergarten, and there is no question but the occupation of paper mat weaving as practiced in the kindergarten should also be introduced in the lowest primary grades for those who have not had kindergarten training, because of its value in simple manual work and in designing symmetrical patterns and harmonious color combinations.

By general consent colored papers have been chosen as the most available material for this work, because while relatively cheap, the purest colors possible in pigments are secured, and the material is adapted to the most elementary manual training and education in form as well as color.

It is not the author's aim to here provide a definite course of lessons to be given in a perfunctory [Pg 78] way or in a fixed order, but rather to furnish suggestions based on practical work in the schoolroom that may be of value to those who have carefully examined the preceding pages of this book and become familiar with the experiments described. The suggestions are based on the experience of teachers who have been using the system here advocated for several years and testing it in various ways, and therefore it is hoped that they may be of value to any earnest worker who is not fully satisfied with her efforts in teaching color up to date. Consequently a brief outline of work is suggested for the earliest years, according to a definite order, and then further suggestions and experiments are introduced, somewhat in the order in which they may naturally present themselves.

The time has passed when it is necessary to offer any argument for the study of color in the schoolroom. Every child begins his school life with many color impressions which he has been acquiring since the day when his baby fingers first stretched toward some bit of color, and his development demands a clear presentation to him during the earliest school years of the fundamental facts concerning color upon which all later work must be based.

The Glass Prism.

A glass prism is one of the first requisites in the appliances for teaching color, and a prism which may be bought for a few cents will work wonders in the hands of an interested teacher, although a more perfect instrument, such as is sold with physical apparatus, will give colors which are better defined.

Experience in many schoolrooms has proved that a spectrum can be shown somewhere in the average room at some hour in every sunny day, especially in the longer days of spring and summer, and it is well to have the prism when not in use so fixed as to project the spectrum into the room much of the time, so that it may become familiar to the younger children.

Observation of the spectrum enthuses the children with a feeling for color which can be [Pg 79]
developed in no other way, and they never tire with watching the wonderful vibrating effects of the liquid colors; and by studying it the mental image of each of the six colors becomes as distinct as that of the cube after it has been handled and modeled. If the schoolroom is provided with shutters or dark curtains a much better spectrum can be produced by closing them, as even a slight change from a bright sunny daylight has a very perceptible effect in bringing out the colors. A person who has never seen a carefully prepared spectrum in a room almost perfectly dark can have no realizing sense of the purest possible expressions of color.

Accident once disclosed a simple means by which one teacher secured a very good spectrum. There was a deep, dark closet opening from the schoolroom and one bright day when the prism was being used the spectrum was accidentally thrown into this closet, and the sudden and enthusiastic expression of approval by those pupils who were in position to discover it was certainly interesting to the teacher of that country school, with a dark coal closet.

In a spectrum such as can be produced in a dark room with the most perfect form of prism, all the various colors can be separated and carefully examined and by special appliances compared with pigmentary colors. Experiments of this kind are exceedingly interesting and instructive, and demonstrate the wonderful intensity and purity of the spectrum colors as compared with the purest pigmentary colors that can be produced. Such experiments were carried to a great degree of perfection when the six standard colors for the Bradley Colored Papers were selected.

How the Bradley Color Standards Were Chosen.

After many months of labor in securing samples of material colors, and many days spent with the spectrum, a committee of artists, scientists, teachers, and artizans unanimously decided that æsthetically and psychologically the colors adopted were the best possible material expression of [Pg 80]
the six localities in the spectrum corresponding to the feeling or psychological perception of red, orange, yellow, green, blue and violet. Many subsequent experiments have apparently proved that practically the same six colors best serve the purpose of primaries from which to make all others by combination.

In accordance with these selections the educational colored papers have been made, and since that time an expert scientist has accurately located each of these colors in the spectrum by its wave length. Consequently after the children have come to know the six colors in the sun spectrum the six standard colors of the papers may be shown as the best imitations possible. In studying the six colors from the spectrum in a schoolroom it frequently happens that one color may be best seen on the floor, another on the wall or even the blackboard, and another on the ceiling, and after the order of the colors in the whole spectrum has been observed, it is well to get each color where it can be best secured.

Paper Color Tablets.

When the spectrum has been studied so that the children have some idea of the six colors and their location relative to each other, give each of the children a package of the colored paper tablets, one inch by two inches, containing the eighteen normal spectrum colors, i.e., those in the central vertical column in the Chart of Pure Spectrum Scales, Page 41, and tell them to select from the eighteen the six which they have seen in the spectrum and which may be named to them as red, orange, yellow, green, blue and violet. [C]

If a sheet of neutral gray cardboard can be secured for use on each desk all early color work will be more valuable, because of the undesirable effect of the usual yellow or orange color of the wood of the desk.

If some of the pupils do not make the correct selection of the papers it may be well to let the error pass for that time and have another exhibition of the spectrum before the next trial. Get as many of them as possible to make the selection of the six colors from the eighteen solely by comparison with the spectrum. Later if some are still unable to succeed, a paper spectrum may be shown to them, or what is better, six bits of paper like their own, pasted on a card, with an interval as wide as two papers between each two. When every child can readily select the six standard colors from the eighteen then all of them may with advantage be told to lay the six in a row on the gray cardboard or desk, in their proper order, and sufficiently separated to allow room for two other papers between each two. When all have made the attempt and some have failed to arrange the papers correctly the card having them properly mounted may again be shown and each one in error may make the necessary corrections by comparison. [Pg 81]

In a solar spectrum such as is possible in the ordinary schoolroom the intermediate colors between the standards cannot be very distinctly seen but the child can be shown that between the red and orange, with which he is familiar, there are colors different from both and possibly he may be led to see that these colors seem to be a mixture of the two. With this impression in the minds of the children the following experiment may be a very interesting psychological test of the natural color perception of each child, or in other words his "color feeling."

Ask the children to arrange the remaining twelve papers between the six standards in pairs and one outside of the red and violet at the ends. This exercise will serve to bring each of the other colors to the critical attention of the children so that they may not be entirely strangers to them in the succeeding exercises. At this stage the color wheel or color top or both will be most valuable. [Pg 82]

Color Wheel or Top.

If the wheel is available let the teacher place on it combined red and orange disks of medium size and in front a small red disk. Before beginning the six papers should be laid on the desk in order, separated by two spaces. Call attention to the fact that the red disks are like the red sample of paper. Explain how the disks are joined and that the two larger ones can be made to show more or less of the orange and the red.

Then introduce a small amount of orange, perhaps not enough to cause the effect to be perceived by the children when the wheel is in motion, and rotate. Ask if they see any difference between the small disk at the center and the larger surface. Add more orange till they see a difference, and continue to add orange to the red until nearly one-half the disk is orange or till it may be questionable whether the color made by rotation is more nearly orange or red. This point will be reached before the orange nearly equals the red, because the orange is more luminous. Explain that all these colors which the children have been seeing are orange-reds and ask the pupils to select that color from their papers which is orange-red, or most like the orange and red. In the meantime set the orange and red disks to the proportion of R. 85, O. 15, which nearly or exactly matches the orange-red paper. When the children have selected the paper which they think is orange-red, put the wheel in motion and ask them if their selection is like the color on the wheel. If not, see that all understand and have selected the orange-red paper to place next the red sample. When this has been done remove the disks from the wheel and readjust the larger ones so as to show a combination that is nearly all orange; then replace them and substitute in front a small orange disk instead of the red one and proceed to show a series of red-orange colors from the orange toward the red, as previously shown from the red toward the orange.

With experiments before adults this break in the order of proceeding and the change of disks would be unnecessary, but with children it is desirable to mark a distinction between the orange-red and the red-orange colors, a fact which is emphasized by the mechanical manipulation. When the children have been asked to place their red-orange paper in its proper position the disks may be set to R. 50, O. 50, and an imitation of their red-orange paper shown. [Pg 83]

If the school is provided with color tops their use may be begun at this point by allowing the children to attempt to repeat the wheel experiments with the tops and thus produce for themselves an imitation of the two intermediate spectrum hues in the papers. In all combinations of colors by disks as well as pigments there is some loss of purity and hence the colors of papers in the intermediate hues may be a little brighter in some cases than the results of two disks in combination.

This suggestion for the presentation of one pair of the intermediate spectrum hues may serve to illustrate all the others, and the time which can be devoted to the whole subject must determine the detail with which each pair is treated.

If the tops are provided in a school but no color wheel then the teacher must begin with a top as a substitute for the wheel and let the children follow her with their tops by dictation. At first this will be much more difficult than if the wheel could be used, but after the children have become somewhat familiar with the handling of the top by dictation the result will be quite surprising. There will be in every school some children who are exceedingly awkward in the manipulation of the top, until the happy day arrives when all school children are graduates of kindergartens. At present the average kindergarten pupil will handle the top better than the children in the lowest primary grades who have not had the advantages of kindergarten instruction.

When all the hues except the red-violet and violet-red have been located, the teacher should be prepared with a chart made by pasting the eighteen paper samples, including standards and intermediate hues, in their order on a strip of paper, so that by bringing the ends together the children may see that when they place the violet-red at one end of their row and the red-violet at the other they are really completing a spectrum circuit and forming a chart of natural colors. Ever since Newton's day it has been fashionable to speak of the spectrum as nature's chart of colors. This expression is but partially true and is entirely false if we mean that it contains examples of all the colors in nature. The spectrum is valuable in color study only from the fact that it enables us to establish permanent standard colors from which all colors in nature and the arts may be named and by the combinations of which such colors may be imitated. [Pg 84]

Unless the standard colors in a system of color instruction are the closest possible imitations of corresponding spectrum colors there is no logical relation between such a system and a chart of colors based on the spectrum, because the spectrum does not furnish a complete circuit of colors and its only value is, as before stated, in furnishing a permanent standard on which to found a nomenclature of colors.

Up to this time we have not suggested the practice of introducing any natural objects or calling the attention of the children to various colors found in their surroundings. Each teacher must use her judgment regarding this matter, but as soon as miscellaneous colors are to be considered the two questions of hues and tones are necessarily involved, and experienced teachers have been divided in their opinions as to which should be first considered, tone or hue. When it was thought necessary to occupy a long time in presenting all the spectrum colors this question assumed greater importance than at present, but very many teachers have become convinced that we have not been giving the children credit for nearly as much ability in the recognition of colors as they deserve, and that with the methods at present in use the six standard colors and twelve hues can be learned in a few weeks, during which time it may not be necessary to discuss the complicated combinations of colors in nature and our domestic surroundings. This is not intended to mean that the child will in this time be able to name the various hues when seen separately, but that having the eighteen paper tablets he may feel their relations to each other to such an extent as to be able to lay them in their spectrum order. Those pupils who seem to have no natural perception of the proper relationship of colors will require more experience than the rest of the class before they can be sure of their colors and the teacher must exercise her judgment in deciding how long to hold the class to this subject of spectrum hues on their account. [Pg 85]

As in other class work it is not necessary that the dull children perfectly comprehend all that is told them at each step, because there will always be some in a class who will comprehend and thus the others may learn by observation, and in this subject particularly every step in advance must necessarily include a continual review of all that has preceded.

Consequently when a teacher has given as much time to the study of hues in the arrangement of the papers as she deems profitable, considering the entire time that can be devoted to the subject during the year, she may well proceed to tones.

The Study of Tones.

It is unnecessary at the beginning to use the word tones with the children, as "light and dark" colors will be understood more clearly. The first lesson in light and shade may be given with some book bound in a bright color, as red for example, which is common in cloth bindings. For this experiment partially open the book and hold it vertically, with back toward the class, in such position that a strong light from one side of the room will fall directly on one cover while the other is in the shade. If properly manipulated this simple experiment may be made effective to an entire class by moving the book in various directions to accommodate the several members, so that at different times all the pupils may get very clearly the idea of light and dark colors in the same scale. [Pg 86]

This idea can be more clearly shown by means of a simple model very easily made for the purpose. Take, for example, three pieces of standard red paper, 4×4 inches, and mount them on a piece of cardboard side by side, in a row. Trim the card parallel to the edges of the papers, leaving a margin of uniform width, and with the point of a knife "score" a line partially through the card from the front, at the joining of the papers, so that it can be neatly bent to the form shown in Fig. 16 which represents the model as seen by the class. By holding one of the rear edges with each hand the faces can be folded to different angles with each other and the model turned to different positions with relation to the children. Possibly the windows at the rear of the room may be partially darkened to advantage; they certainly can be if they have a sunny exposure at the time. The object is to give a fair daylight on the central surface for the standard, a strong light on one side to form a tint of the standard and a shadow on the other for a shade of the same color.

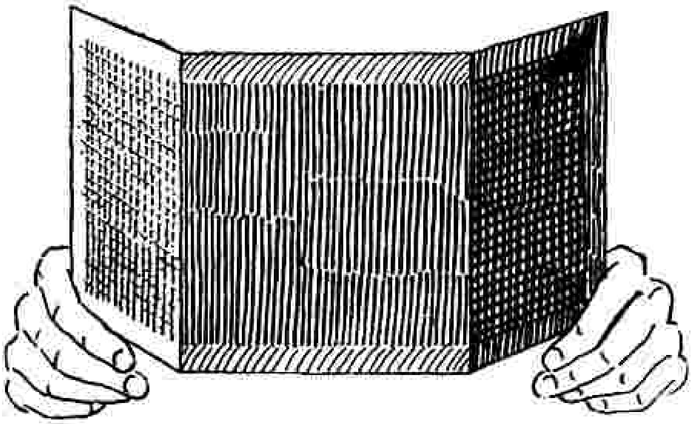


Fig. 16.

By a trial before school, in company with some other teacher perhaps, the best positions for different parts of the room as well as best lighting of the room may be determined in advance and thus such a success achieved with the first experiment that the whole idea of tint and shade may be impressed on each child for all time and definitions firmly fixed in his mind for these two most abused words in our every day vocabulary. Added interest may be excited by showing similar [Pg 87] models in several other colors during the same lesson, thus avoiding the possible impression on any mind that the term tint and shade apply to any special color.

Tints and shades may also be shown very beautifully by some kinds of colored materials. Colored satin ribbons, folded or crumpled, and velvets and plushes give good object lessons. One of the most effective exhibitions of tints and shades may be found in a material used for upholstering furniture and technically called "crushed plush," which is a worsted plush embossed in figures and very changeable in its effects as its relation to the light is changed, giving at the same time very light tints and very dark shades in different portions.

Having thus shown how real tints and shades in nature are produced, the color wheel may be introduced with advantage. If it were practicable to use opaque colors in the school they could be employed to show that the effect of a tint is produced in pigments by mixing white with the standard color and a shade by mixing black with it, but while the mixture of white may produce the best imitations of some tints in nature, the same result does not hold good in the use of black to form shades, and black pigments are rarely used for this purpose, because they impart various untruthful hues, according to the colors with which they are mixed.

For this reason, and others which will appear later, the white and black disks of the color wheel are found to be better than any other single method for representing tones. In shades the black disk produces by far the best imitation of nature, and so does the white disk for more than half of the colors. But, as previously stated, there is an effect which has never been satisfactorily explained by which the tints of red and blue especially receive an unexpected violet gray tinge by rotation. Therefore in showing tints on the wheel it is well not to show very light tints of red or blue until the class has received some impressions of tones in other colors. In the orange and violet the tints seem to be practically perfect, and in the yellow and green not far from correct, [Pg 88] but in the green they run a trifle toward the blue and in the yellow become a little gray or broken. But in the shades the black disk has done wonders for color instruction, particularly in making standard neutral grays which cannot be imitated by white and black pigments, and in determining the shades of yellow, as has been explained. See Page 36.

Therefore, after having shown actual tints and shades with the folded models, and perhaps the other materials suggested, place a colored disk combined with a white disk on the wheel, and in front of them a smaller colored disk of the same color as the larger one for comparison, and by changing the relative proportions show various tints. Then substitute a black disk for the white and show shades. If, for example, orange is taken, all proportions of both tints and shades may be shown very truthfully, the deeper shades being very rich browns. Having in this way impressed on the children the terms tints and shades, give them the paper tablets, Selection No. 2, in the deepest tints and the lightest shades, reserving the lightest tints and deepest shades found in Selection No. 4 for later use.

Let each member of the class lay the spectrum in the normal colors and then select the six tints corresponding to the six standards. When all of them think they have done this, tell them to choose the corresponding shades. If a number fail in the attempt it may be well to set up three sizes of disks on the color wheel in shade, standard and tint of red. In showing a tint of red with the disks it is not a good plan to make a tint lighter than R. 95, W. 5, which is about R. T. 1. If the wheel is not available samples of papers may be held up in the three tones so that the class can get the correct idea. There is no best method of reaching all pupils in any class, but in some way at this point in color education every pupil ought to acquire such knowledge of the subject as to be able to select at least the six standard scales in three tones, and this should be practically [Pg 89] accomplished before much time is devoted to the consideration of such materials as flowers, fabrics and miscellaneous papers, because until the child understands both hues and tones he can do nothing in either analyzing or naming colors.

As soon as these six scales are familiar to the pupil the selecting of various objects and placing them in general families may be very valuable work, but until that time the classification of colors cannot be carried out very accurately, or at best the families will be very likely to include some uncles, and cousins and aunts, and yet, on the other hand, if even the distant relatives are recognized in preference to strangers the choice will give evidence of a sympathetic feeling for color relations, favorable to future progress and indicating something of the natural color sense of the child.

If such occupations as paper cutting and pasting, or weaving of mats have a place in the school, combinations in two or three tones of the six standards can now be made. At this stage names are of little importance, but they will come in play early, as it is natural to give names to everything, and as soon as the child knows the definite names which belong to colors they will be used.

Neutral Grays.

Immediately following the first idea of tints and shades or tones, the grays should have attention, because in the occupations with papers they will play an important part. For this purpose white, black and the neutral gray papers are included in Selection No. 2 of the paper tablets and should be made familiar to the children while the tints and shades are being studied. The suggestion that a neutral gray is a tint of black or a shade of white may or may not aid a child to better understand the relation of the neutral grays to the color chart, but it is a thought worthy of the attention of the teacher, as expressing a fact important in the consideration of color impressions. This gray may also be illustrated on the wheel by the union of white and black disks, and should [Pg 90] be early presented in this way, because this is the only means by which we can secure standards for pigmentary neutral grays, and the fact that this special and peculiar gray is so important in all color investigation furnishes sufficient argument for making it prominent before the other grays.

Even at this early period in his color education a child may be shown that white in shadow is a gray, and the fact that it is a neutral gray is not essential to him, as he has no knowledge of any other gray and probably it may not be desirable to call attention to the various classes of grays until after the broken colors have been studied. A sheet of white card or heavy paper may serve to show that white in shade or shadow is a gray.

For this experiment fold the card or paper very sharply and hold it with the folded edge vertical and projecting toward the class, and in such a position relative to the windows that half of the paper is in very full light and the other in shadow.

A comparison of neutral gray paper No. 1 with a true shade of white or white in shadow, as explained on Page 36, will serve to connect the gray papers with the shades of white. After the idea of tones is made clear to the children, so that they can readily form the six standard scales in three tones, the completing of the Chart of Spectrum Scales in three tones will be merely a matter of drill, as no new principles are involved.

When the pupils can lay the Chart of Pure Spectrum Scales in three tones correctly, the thoughtful teacher will naturally ask herself what is the next logical step, and it may at first seem as though the completion of the chart in five tones ought to immediately follow. But it is very desirable that the pupils begin as early as possible to make a practical application of their knowledge of colors to the familiar objects around them; and it is evident that before any very accurate comparison of miscellaneous colors can be intelligently undertaken the child should be [Pg 91] able to recognize the effect of mixing gray with a color, in distinction from the pure tints and shades of that color.

Explanation of Broken Colors.

Very few of the common colors seen in fabrics and house furnishings are either full pure colors or their tints and shades, but nearly all are broken colors. Therefore it seems desirable to introduce the study of broken colors, before considering the extreme tones of the pure colors as represented in tints and shades No. 2 in the Chart of Pure Spectrum Scales in five tones.

This order of presentation seems specially advisable, because the distinguishing of the extreme tones where the color is lost to so great a degree is more difficult than anything connected with the subject of broken colors. Therefore at this point paper tablets, Selection No. 3 are introduced. From this collection of tablets when properly arranged a Chart of Broken Spectrum Scales of twelve colors in three tones may be made, and in addition there are tablets illustrating the several classes of grays other than neutral grays.

The first result desired is a definite distinction in the mind of each pupil between a broken color and any tint or shade of the same color. In order that the explanation of this distinction shall be intelligently comprehended each child must have such a clear idea of the meaning of the terms "tints" and "shades" that he shall not fail to readily understand any statement regarding them because of confusion as to the definite meaning of these terms. The child should know clearly that a "tint" is a color in a strong light or mixed with white either in pigments or disks, while a "shade" is a color in shade or shadow, i.e. with less than the normal illumination, or mixed with black. When this has been fixed in the mind of a pupil, and he has also been shown that neutral gray, the only gray he has learned anything of, is the result of the combination of white and black, it will not be difficult for him to see that a broken color is produced by the mixture of both white and black with the pure color. Much later it will be possible for him to think of a broken color as a tint thrown into a shade or shadow, as may be observed by casting a strong shade or shadow on to a piece of colored paper in some one of the *tints* of the spectrum scales. [Pg 92]

The color wheel and tops furnish the simplest and most effective means for the presentation of broken colors, because they automatically analyze every color shown, so that the pupil sees for himself just what has been done.

An Exercise in Broken Colors.

After having refreshed the minds of the class as to tints and shades and grays by a brief restatement of the conditions involved in these terms, the idea of broken colors may be shown with disks on the color wheel or top. For this experiment place on the spindle, for example, a combination of orange, white and black disks, and in front of these disks put combined orange and black disks of smaller size. Make the proportions of the larger disks, O. 15, W. 4, N. 81, and the smaller, O. 26, N. 74. In rotation the larger ring will show a dark broken orange and the inner one a dark shade of orange, and the difference in quality will be readily seen and felt. The effect is more valuable as a lesson if the tones of the two are nearly equal, although this is not necessary.

A very much lighter pair of colors is secured by using the following formulas, O. 43, W. 26, N. 31, and O. 77, W. 23.

Both these experiments may be made with the primary color wheel or color top. If the High School Color Wheel is in use so that the four rings of color can be shown at one time, the two larger rings may show two tones of broken color and the smaller rings a tint and shade of pure color.

In the use of tops two may be spun at once as near together as possible, the two broken tones on one top and the tint and shade on another.

In green similar experiments may be tried, with the following formulas:—

[Pg 93]

G. 20,	W. 6,	N. 74.
G. 36,	W. 13,	N. 51.
G. 34,	N. 66.	
G. 82,	W. 18.	

Practically the same methods may be adopted in the study of broken colors as were employed with the pure colors.

The paper tablets contained in Selection No. 3, comprising broken colors and grays, will now come into use to accompany experiments with disks in broken colors. The tablets in the broken spectrum colors number thirty-six, comprising twelve scales of three tones each, thus producing but one intermediate hue between each two standards, instead of two, as in the chart of pure colors.

Exercises in selection and arrangement of these tablets to form a chart may be employed to familiarize the pupils with the new kind of colors. The colors are not so pronounced as in the pure scales, and for this reason the arranging may be more difficult, but the smaller number of hues simplifies it somewhat, so that, with the better-trained color perception which the child will have acquired at this stage, no greater effort will be required than in the earlier lessons.

When the Chart of Broken Scales can be laid with reasonable accuracy by the majority of the class the two charts as far as studied, each in three tones, may be laid on the desk at the same time for comparison and thus the difference in quality or character emphasized.

All kinds of materials may now be considered and classified, and great interest inspired in the subject generally. Flowers, autumn leaves, dress goods and anything with color can be studied and the colors analyzed. Before the study of broken colors was taken up some few flowers could be quite accurately matched with the disks and analyzed, but now very many more of the flowers and plants as well as other material can be accurately analyzed and a definite nomenclature given to each sample.

Selection No. 3 of tablets contains, in addition to the twelve scales of broken colors, six colored grays, which must at some stage be considered in connection with gray colors or broken colors, to which they are closely related. As has already been stated, there is a point where by the continued addition of gray to a color, the color is so far obscured that its identity is practically lost and the result becomes a colored gray. [Pg 94]

Although the line between gray colors and colored grays cannot be definitely drawn there are so many grades visible beyond the point where the exact color used with the gray can be determined, that the term "colored gray," which covers the three classes, warm, cool and green grays, is convenient for common use.

It is very desirable that a distinction be observed between the terms "colored grays" and "gray colors," and therefore broken colors may be a better term to apply to the gray colors because a distinction is thus more strongly emphasized between these two classes of colors.

The following table furnishes formulas from which the colors of the Chart of Broken Spectrum Scales may be very nearly imitated on the High School Color Wheel. Each scale should be shown by the three smaller sets of disks, namely, the smallest for light tone, next size for standard or medium, and the third size for darkest tone.

This list of disk combinations is furnished here for the convenience of teachers who may have occasion to illustrate the compositions of the various classes of colors comprised in the Chart of Broken Spectrum Scales, which covers the entire range of the æsthetic colors and from which by modifications every subdued color in material substances can be analyzed and definitely named.

Owing to the color usually found on the interior of a school-room and the lack of pure white light from outside it is not probable that these proportions will exactly match the papers, but the formulas will enable the teacher to approximate the color, and then the more accurate match in [Pg 95] conformity to the conditions in each case may be secured by making changes in accordance with suggestions from a majority of the class, an exercise which will afford valuable practice for the pupils.

Formulas for a Chart of Broken Spectrum Scales.

	LIGHT.	MEDIUM.	DARK
RED	R. 68, W. 18, N. 14.	R. 59, W. 5, N. 35.	R. 22½, W. 5, N. 72½.
ORANGE RED	R. 51, O. 17½, W. 23, N. 8½.	R. 47, O. 16, W. 8½, N. 28½.	R. 15, O. 7½, W. 7½, N. 70.
ORANGE	O. 43, W. 22½, N. 24½.	O. 34½, W. 10, N. 55.	O. 15, W. 5, N. 79½.
YELLOW ORANGE	O. 23, Y. 15, W. 27, N. 35.	O. 24½, Y. 17½, W. 15, N. 43.	O. 10, Y. 4½, W. 6, N. 79½.
YELLOW	Y. 34, W. 30½, N. 35½.	Y. 24, W. 12½, N. 63½.	Y. 12½, W. 5, N. 82½.
GREEN YELLOW	Y. 24, G. 13, W. 28, N. 35.	O. 24½, G. 10, W. 17, N. 48.	Y. 11, G. 13, W. 10, N. 66.
GREEN	G. 16, W. 9, N. 75.	G. 34, W. 19, N. 49.	G. 23, W. 41, N. 36.
BLUE GREEN	G. 8½, B. 7½, W. 7, N. 77.	G. 22, B. 18, W. 12, N. 48.	G. 24, B. 25, W. 23, N. 28.
BLUE	B. 22½, W. 6, N. 71½.	B. 38, W. 13, N. 49.	B. 36, W. 29, N. 35.
BLUE VIOLET	B .13, V. 9½, W. 6½, N. 71.	B. 13, V. 25, W. 15, N. 47.	B. 20, V. 15, W. 29, N. 39.
VIOLET	V. 20, W. 13, N. 67.	V. 51, W. 24, N. 25.	V. 61 W. 32, N. 7.
RED VIOLET	R. 17, V. 10, W. 5, N. 68.	R 16½, V. 45, W. 13, N. 25½.	R. 23, V. 40, W. 26, N. 11.

In preparing the papers for the Chart of Broken Spectrum Colors the selection of the tones of the several colors has been made in accordance with the æsthetic color feeling of those to whom the matter was intrusted, but the hues of the colors are based on the standards of the pure spectrum colors.

If these colors are considered independently of their relation to a general system of color education, it may seem that a stronger and purer line of colors would be more beautiful; but the [Pg 96] more broken or subdued colors have been chosen after very careful consideration, because they are intended for elementary instruction and therefore should be so far removed from the pure color scales as to impress themselves on the minds of the children as a distinct and representative class of colors. When the color sense of the pupils has been sufficiently cultivated to observe smaller distinctions, a variety of color scales much less broken may be shown with the disks.

Different selections for a score of charts could be made, all beautiful and representing broken colors, but after much consideration these thirty-six were selected from a very large number of hand-painted samples made for the purpose, as furnishing a sufficient number of typical broken colors for elementary color instruction, and in such hues and tones as to form a harmonious chart for comparison with the Chart of Pure Spectrum Scales.

Certain "Color Puzzles."

When the children have advanced far enough to understand the analysis of a color, i.e., to correctly name a color, exercises which may be called color puzzles can be introduced from time to time with great interest and profit.

The idea is simply to suddenly show to the class a series of disks in rapid rotation and ask them to guess what colors it is composed of, i.e., what the definite name of the color is.

The following is a suggestion for this exercise, supposing that a broken green yellow is to be shown:—

Select a green, a yellow, a white and a black disk of medium size and combine them as follows: Y.20, G.10, W.10, N.60. Then, having previously removed the nut from the spindle of the wheel and laid it in a convenient place, take the combined disks and lay on the top of them any other disk of a larger size, with the center holes of all corresponding with each other and place all these disks on the spindle of the wheel with the larger disk still covering the face of the others. Having previously furnished an assistant with a sheet of cardboard of sufficient size to conceal [Pg 97] the disks from the class have it held in front of the wheel while the disk which conceals the combination is removed, the nut screwed to place and the disks put into rapid rotation; then order the card taken away and ask the class what color they see, still continuing the rotation.

The correct answer should be broken green-yellow, and not a shade of green-yellow, a broken yellow-green, a tint of yellow or a yellow shade; for there is but one true name and that should be stated. Definite expressions of color are as possible as the terms used regarding other scientific subjects, and should be encouraged.

Much interest can be inspired and valuable instruction imparted to the children by experiments with the color wheel, but whenever color analysis is the object in view, if disks of more than one of the standard colors are used in the same combination they must be of colors adjacent to each other in the spectrum.

For example, if a blue and a yellow disk are united and placed in rotation the result may be a blue gray, a yellow gray, or perhaps very nearly a neutral gray, because blue and yellow are so nearly complementary to each other. But a nomenclature of the resulting color effect expressed in terms of blue and yellow is not of practical value, because it is evident that in the analysis of a gray-blue, yellow has no logical place. If in an attempt to match a color which seems to be a broken blue, something else besides the blue, white and black is required, it must be either green or violet, i.e., one of the two standard colors adjacent to the blue in the spectrum. In other words, every color in nature is a spectrum color, i.e., either a pure spectrum color, a tint or a shade of a spectrum color, or a broken spectrum color. Hence every color can be matched, and therefore analyzed by the combination of one disk of a standard color with a white disk, a black disk or both, or else by two adjacent spectrum standards with white and black or both.

There are many combinations of disks outside the limitations above named which are valuable [Pg 98] and interesting in color investigation when not used for simple analysis, but if they are presented as pleasing experiments before the pupils can understand their logical relation to the subject of color education, the result may be entirely misleading rather than instructive.

In making experiments in broken colors with the wheel the most satisfactory results are secured in orange, violet, green and yellow, while the red is fairly good and the blue less satisfactory than the others because of the slight effect of gray or violet which comes into the lighter tones by rotation, to which reference has already been made.

As explained on Page 54, the so-called tertiary colors, russets, citrines and olives were formerly supposed to be classes of peculiar colors to which these names were given. The fact that these are all broken spectrum colors was first demonstrated by the use of the color wheel and they are now quite generally accepted as such by those who have given heed to modern methods of color instruction.

As already shown the disks have also seemed to correctly define the several scales of colors, so that in contrast to the color charts of a dozen years ago a distinction is clearly drawn between the colors in the yellow and the orange scales, or even between the yellow-orange and the orange-yellow scales, so accurately do the disks determine the hue of a color.

When the pupils have progressed so far that they can arrange the paper tablets to form the Chart of Pure Spectrum Scales in three tones and also the Chart of Broken Scales, they will be prepared to intelligently begin the use of papers in cutting and pasting designs in the several classes of harmonies, but before most effective results can be produced the lightest tints and deepest shades of the full chart of pure scales in five tones must be considered.

Chart of Pure Spectrum Scales Completed.

The entire mastery of these extreme tones will be quite difficult because they are so far removed from the standards, and the children can hardly be expected to recognize and name them when [Pg 99] seen separately. If a pupil is able to correctly arrange them in connection with the other tones of the chart, his accomplishment will show a high grade of color perception. But these extreme tones are introduced because their use in the more advanced work of paper cutting and pasting produces stronger and more beautiful harmonies and a higher degree of color training than would result were the tints and shades nearer the standards in tone.

No detailed rehearsal of the lessons for this work is necessary to enable a teacher who has pursued the course of instruction thus far to complete it in a logical way, and relatively little time will be required by the pupils to become sufficiently familiar with these tones for practical purposes, because of their more acute color perception which will be developed at this period.

The Work of Cutting and Pasting.

In the study of color the work of cutting and pasting designs in educational colored papers affords the earliest and best practical expression of the color feeling which has been acquired and stimulates the further development of color perception. The order in which the use of these papers can be most profitably taken up in the occupations of cutting and pasting may be determined by a careful consideration of the subject of harmonies as explained quite fully in the foregoing section entitled "Practical Experiments," Pages 67 to 73.

The first in order is Contrasted Harmony, in which cut papers in one color may be mounted on a ground of some passive color as white or gray. In selecting the gray, analogy is usually preferable to contrast, while neutral gray is fairly safe for all colors. According to this suggestion the warm grays may be used with the warm colors and the cool grays with the cool colors, and in a majority of the cases the lightest tone of gray is preferable.

Without question Dominant Harmonies or the arrangement in families are the most profitable [Pg 100] and safe for early practice. In this class a light tint may be used for the background on which to mount any of the other tones of the same scale. Beyond these two classes of harmonies the order of presentation must be determined by the teacher. If the complementary is attempted with simple geometrical forms a light tint may most safely be selected for a background in the least aggressive of the two colors and the design or pasted forms in some of the complementary tones other than the normal color. Do not attempt to combine full complementary colors in elementary work.

The Analogous Harmony may be used in simple designs with beautiful effects when judicious selections are made, but owing to the latitude necessarily involved in the definition of this class of combinations the children cannot very early be trusted to make their own selections.

It is evident that nothing can be attempted in the Perfected Harmonies in any of the ready-cut forms, but beautiful results can be produced in this class with well-drawn and accurately cut ornamental designs in colored papers, which may even surpass in strength and beauty any effects which can be produced in water colors such as can be used by the children.

For earliest practice in making designs in colored papers the ready cut forms of the kindergarten, technically called "parquetry papers" are very convenient and may be procured either with or without gum on the back. These are prepared in various geometrical forms based on the one-inch standard, among which the most useful for pasting decorative designs are the circle, half-circle, square, half-square and equilateral triangle. Where models and tablets are used in form study the tablets may serve as patterns from which the children can mark out the papers which they can then cut for themselves, and thus the oval and ellipse may be added to the forms, and also practice in accurate cutting secured.

In the use of tablets as patterns the outlines should be made on the backside of the paper, by holding the tablet in place with one finger and working carefully around it with a well-pointed [Pg 101] pencil. The marking to the pattern and cutting to the line provides valuable elementary practice in manual training. As it is the prime object of these papers to treat of color no attempt is here made to give directions for designing units of ornament or for folding and cutting designs. All such exercises furnish the best possible practice in both designing and manual work, but they belong more directly to the department of drawing and are fully treated in the hand books explaining modern systems of drawing. We offer here a number of simple arrangements of such forms as may be found in ready-cut papers or may be marked from the form study tablets as before mentioned, with the addition of a few other figures which involve some very simple designs for free-hand cutting.

A Variety of Designs.

The accompanying illustrations show a number of simple arrangements of such forms as are found in ready-cut papers or may be marked from the form study tablets already mentioned, with the addition of a few other figures which include some very simple forms requiring free-hand cutting. Suggestions for more elaborate designs and specific directions for paper cutting can be found in elementary books treating of decorative drawing and those devoted solely to paper cutting.

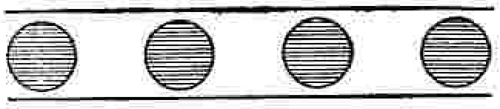


Fig. 17.

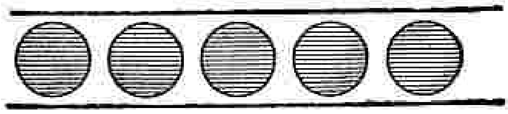


Fig. 18.

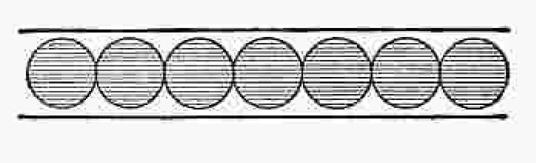


Fig. 19.

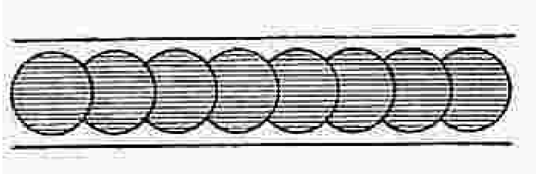


Fig. 20.

Figs. 17 to 25 show arrangements of one-inch kindergarten parquetry papers in one color, used as units to form border designs in contrasted harmony on a white or a gray ground, in all of which there is repetition of form as well as color. A narrow strip of paper in the same color as the units may be used at top and bottom to finish the design.

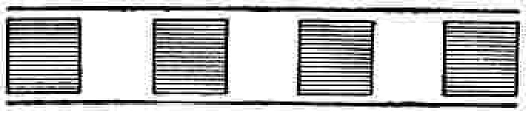


Fig. 21.

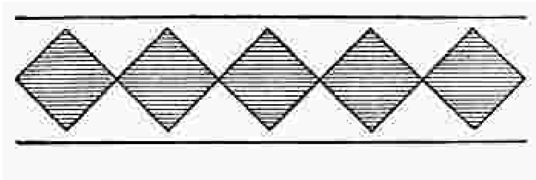


Fig. 22.

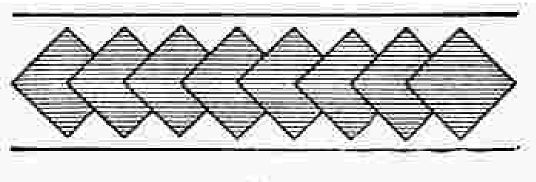


Fig. 23.

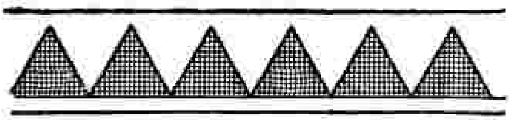


Fig. 24.

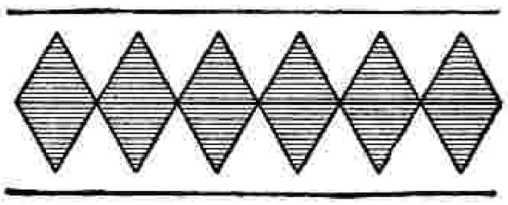


Fig. 25.

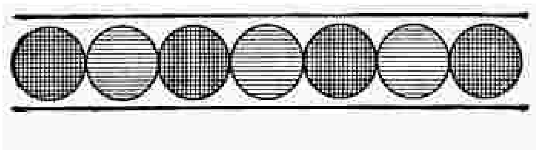


Fig. 26.

Figs. 26 to 37 show border designs, each of which is made with one form in two colors or tones in alternation.

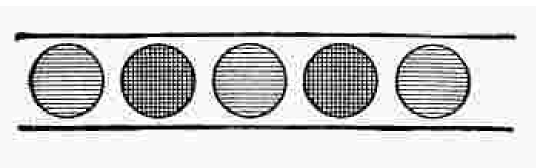


Fig. 27.

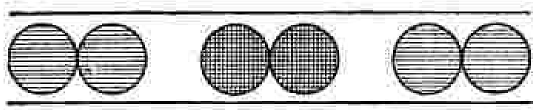


Fig. 28.

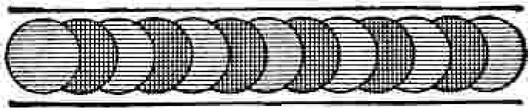


Fig. 29.

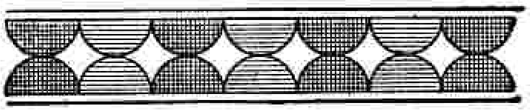


Fig. 30.

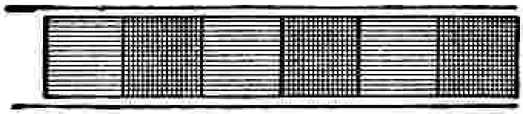


Fig. 31.

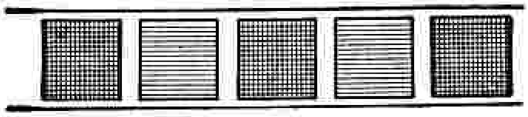


Fig. 32.

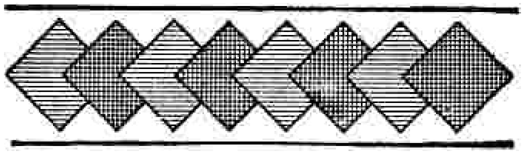


Fig. 33.

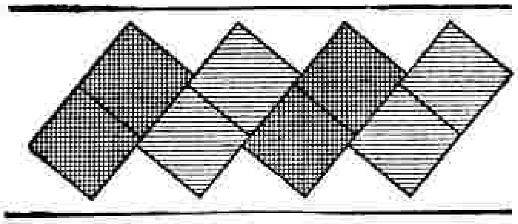


Fig. 34.

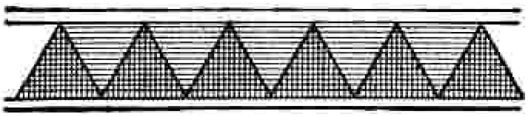


Fig. 35.

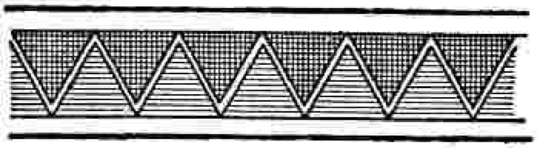


Fig. 36.

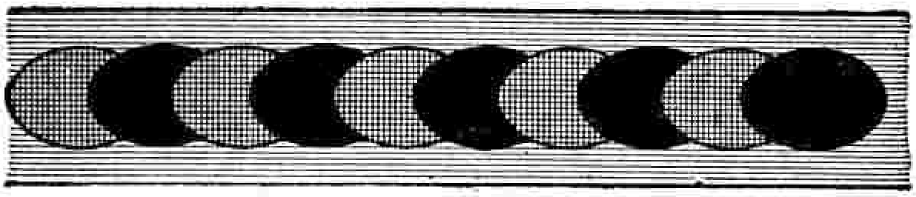


Fig. 37.

Figs. 38 and 39 show border designs in one color, with forms marked from the elliptical and oval tablets and cut by hand. In Fig. 39 borders are made by combining half-squares which may be used with or without narrow strips of the same color.

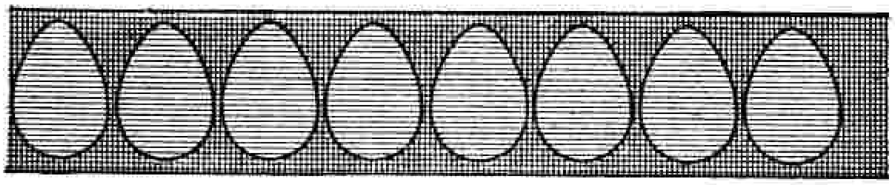


Fig. 38.

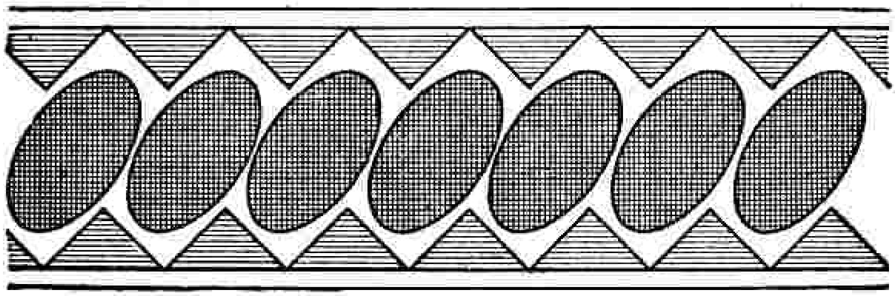


Fig. 39.

Figs. 40 and 41 are made by using one form with alternation of tone and of position. Fig. 41 is derived from Fig. 40 by laying the dark squares with the corners in contact and placing the light squares over them.

Fig. 42 shows alternation of form and color or tone, which is also the scheme employed in Fig. 43 in a design less simple with the addition of the half-circles.

Figs. 44 and 45 show two other simple and pleasing designs with alternation of both form and tone or color.

Figs. 46, 47, 48, and 49 comprise designs in two forms and two tones or colors, in which some hand cutting is necessary on the part of the pupils.

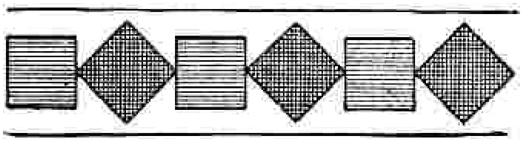


Fig. 40.

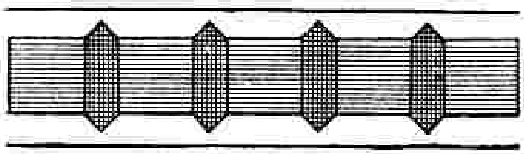


Fig. 41.

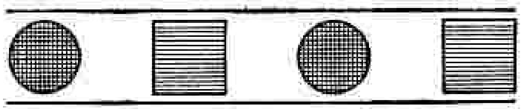


Fig. 42.

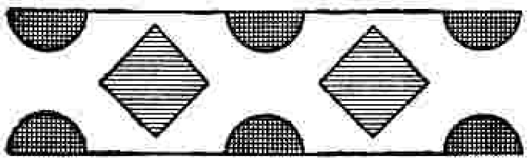


Fig. 43.

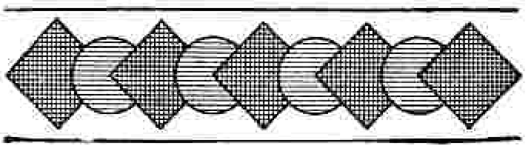


Fig. 44.

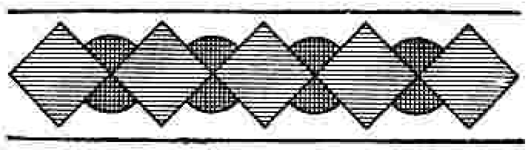


Fig. 45.

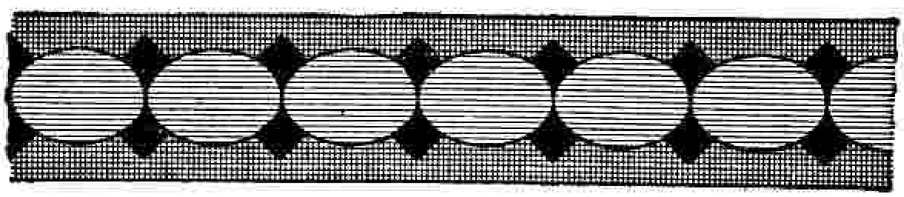


Fig. 46.

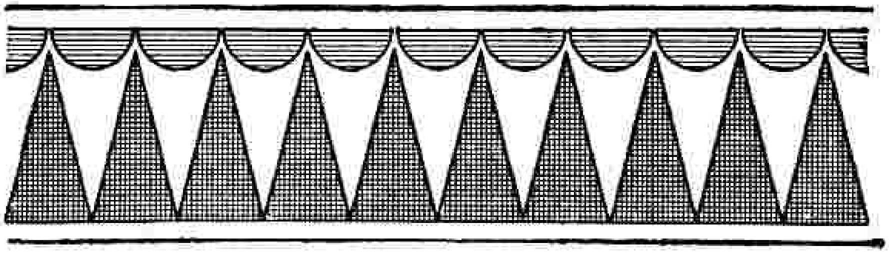


Fig. 47.

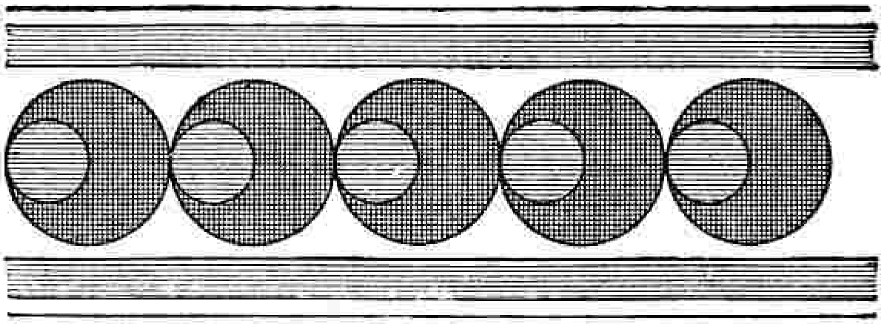


Fig. 48.

Figs. 50 to 54 are rosettes made from parquetry papers with the addition of a small circle or square at the center cut by hand.

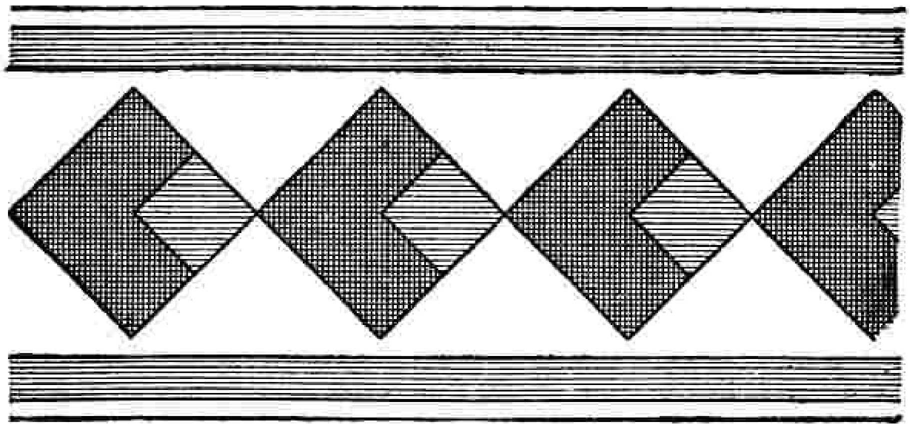


Fig. 49.

Figs. 55 to 60 are principally hand-cut forms, and 61, 62 and 63 show surface patterns made from parquetry squares and half-squares.

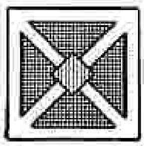


Fig. 50.

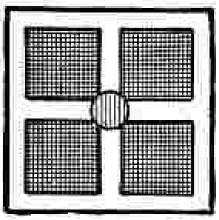


Fig. 51.

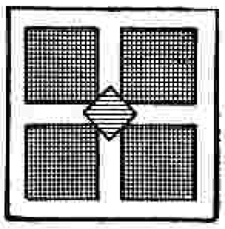


Fig. 52.

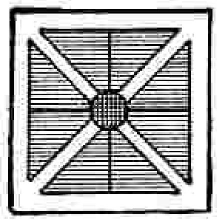


Fig. 53.

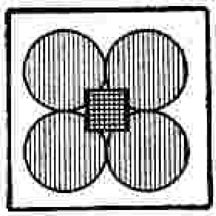


Fig. 54.

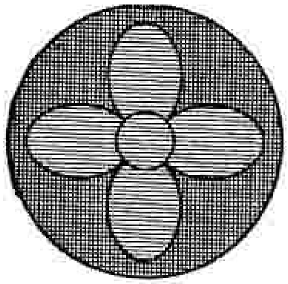


Fig. 55.

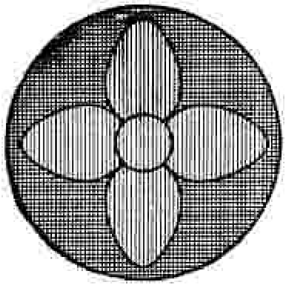


Fig. 56.

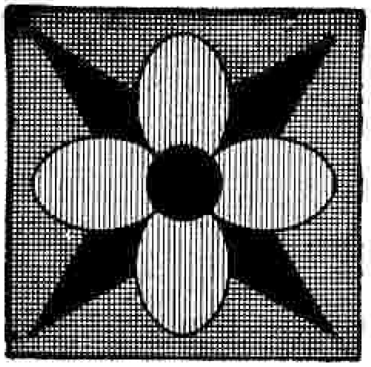


Fig. 57.

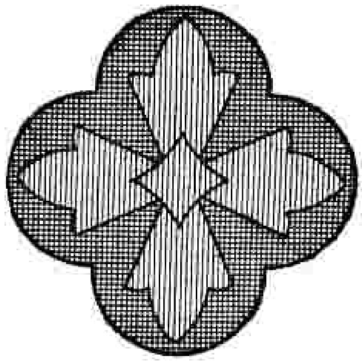


Fig. 58.

[Pg 106]

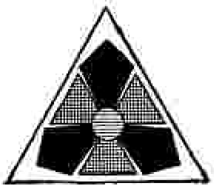


Fig. 59.

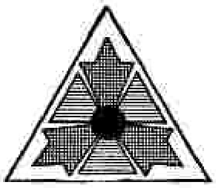


Fig. 60.

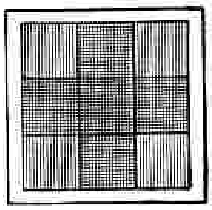


Fig. 61.

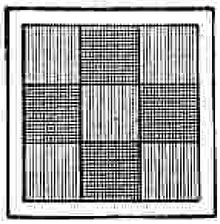


Fig. 62.

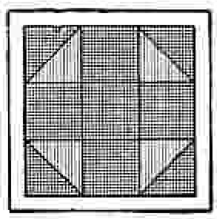


Fig. 63.

Colored papers can be used more advantageously in decorative designs than in imitations of natural objects, for which water colors are much better suited, but some copies of natural flowers and autumn leaves have been made in colored papers which were exceedingly close imitations of water color paintings when seen at a little distance, rivaling in the case of the autumn leaves the best water color effects in brilliancy and depth of color.

There need be no definite rules governing the continuation of color study from this point by a teacher who is interested in the subject and has tried the experiments suggested in the preceding pages. The work will become very interesting at this stage, because now all sorts of material may be introduced for analysis and classification and from this point forward, to the highest achievements of the artist, nature will furnish abundant stimulus to color thought and investigation, if the foundation has been laid according to the true theory of color perception which it is the object of this system to explain.

Analysis of Color Materials.

A valuable and interesting phase of color investigation and color training may be found in the analysis and naming of the natural colors found in flowers, minerals and the plumage of birds. [Pg 107]
The necessity for a definite and adequate nomenclature which naturalists experience in this

department of education has been emphasized by the publication within a few years of a book entitled "A Nomenclature of Colors for Naturalists, and a Compendium of useful knowledge for Ornithologists."

This book has been prepared with great care by Robert Ridgway of the United States National Museum, and contains a large number of hand-painted plates showing nearly two hundred colors which represent selections from three hundred and fifty names of colors which are given in English, Latin, German, French, Spanish, Italian and Norwegian or Danish. [D]

The fact that a book involving so much technical knowledge and the expenditure of so much time and money was deemed justifiable is an evidence of the great need for some definite nomenclature.

In the introduction the author says: "Undoubtedly one of the chief desiderata of naturalists, both professional and amateur, is a means of identifying the various shades of colors named in descriptions, and of being able to determine exactly what name to apply to a particular tint which it is desired to designate in an original description. No modern work of this character it appears, is extant,—the latest publication of its kind which the author has been able to consult being Syme's edition of 'Werner's Nomenclature of Colors,' published in Edinburgh in 1821. It is found, however, that in Syme's 'nomenclature' that the colors have become so modified by time, that in very few cases do they correspond with the tints they were intended to represent."

The following are the opening sentences of the preface: "The want of a nomenclature of colors adapted particularly to the use of naturalists has ever been more or less an obstacle to the study of Nature; and although there have been many works published on the subject of color, they [Pg 108] either pertain exclusively to the purely scientific or technical aspects of the case or to the manufacturing industries, or are otherwise unsuited to the special purposes of the zoologist, the botanist and the mineralogist."

In the same book the Chapter on Principles of Color opens with the following sentences: "The popular nomenclature of colors has of late years, especially since the introduction of aniline dyes and pigments, become involved in almost chaotic confusion through the coinage of a multitude of new names, many of them synonymous, and still more of them vague or variable in their meaning. These new names are far too numerous to be of any practical utility, even were each one identifiable with a particular fixed tint. Many of them are invented at the caprice of the dyer or manufacturer of fabrics, and are as capricious in their meaning as in their origin; among them being such fanciful names as 'Zulu,' 'Crushed Strawberry,' 'Baby Blue,' 'Woodbine-berry,' 'Night Green,' etc., besides such nonsensical names as 'Ashes of Roses' and 'Elephant's Breath.'"

These extracts from this valuable and interesting book by an author of large experience are quoted here to emphasize the practical necessity for more definite color education based on analysis and nomenclature.

With the color wheel or color top, the colors of flowers and leaves as well as all other objects in nature and art may be analyzed and named, and the names definitely recorded in the terms of a nomenclature based on permanent standards.

The following list of flowers and leaves of plants and trees with their analyses in terms of our nomenclature is taken from a recently published paper entitled "On the Color Description of Flowers," by Prof. J. H. Pillsbury, to whom the writer is indebted for some of the earliest suggestions regarding the practical application of the scientific facts of color to color teaching, and also for valuable scientific work which he has done including the exact location of the six [Pg 109] color standards in the solar spectrum by their wave lengths:—

"With these standards to work from, I undertook to determine the color analysis of certain of our common flowers. The following results, will, I think, be interesting to botanists. The numbers given indicate per cent. of color required to produce the hue of the flower:—

Common forsythia,	F. viridissima:	Pure spectrum yellow.		
Fringed polygala,	P. paucifolia:	R. 48,	V. 52.	
Wistaria,	W. frutescens, wings:	R. 11,	V. 89.	
Wistaria,	W. frutescens, standard:	R. 9,	V. 79,	W. 12.
Flowering quince,	Cydonia japonica:	R. 95,	V. 2,	W. 3.
Wild cranesbill,	Geranium maculatum:	R. 28,	V. 66,	W. 6.

The variations of color in the early summer foliage is also interesting. The following analyses are for the upper side of fresh and well developed healthy leaves. It is not impossible that a little attention to these variations in the color of foliage on the part of artists would save us the annoyance of some of the abominable green which we so often see in the pictures of artists of good reputation:—

White oak:	Y. 7.5,	G. 11.5,	N. 81.	
Apple:	Y. 5,	G. 13,	W. 2,	N. 80.
Copper beech:	R. 17,	V. 2,	N. 81.	
Hemlock:	Y. 2,	G. 9,	N. 89.	
White pine:	Y. 2.5,	G. 11,	N. 86.5.	
White birch:	Y. 5.5,	G. 11.5,	W. 1,	N. 82.
Hornbeam:	Y. 5.5,	G. 12.5,	N. 82.	
Shagbark hickory:	Y.4.5,	G.9.5,	N.86.	

These analyses were made in a moderately strong diffused light with Maxwell disks of the standard hues referred to above."

These are but a few of the numerous flowers the colors of which may be perfectly imitated and consequently analyzed and named with the color wheel or the top. In fact for individual work in natural history the top is more convenient than the wheel and sufficiently accurate for all [Pg 110] practical purposes, while it is a very fascinating occupation for child or adult.

In the use of disks for analyzing colors it must be remembered that every material color is some quality of some color in the spectrum circuit, and therefore may be matched with not more than two standard disks, either alone or with white or black or both. If more than two color disks, besides white and black, are used they will neutralize each other more or less, and a neutral gray or a gray and some spectrum color will be the result. For example, if yellow and blue in nearly equal parts are introduced in connection with red and orange, the yellow and blue being nearly complimentary to each other will produce practically a neutral gray, and the result will be the same as if only red, orange, white and black were used.

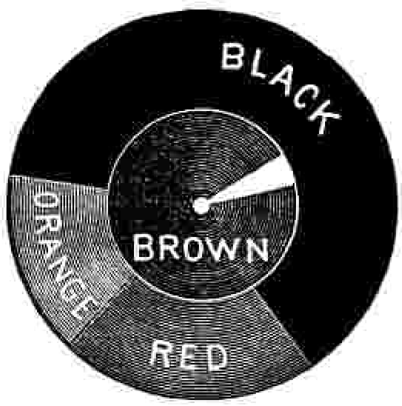


Fig. 64.

Owing to the recent advances in the art of dyeing there are some textile goods which are too intense in color to be exactly imitated by the disk standards, but this fact need not prevent a practical analysis of such colors, because by very slightly reducing with white the color to be examined the same color is retained, the modification making it, of course, somewhat lighter. Fig. 64, showing a small circle representing a disk of the material mounted on thick paper, illustrates this statement. Suppose we have a piece of rich brown cloth, so intense in color that when red, orange and black are combined in the proportions of R. 22, O. 16, N. 62, the material is still a [Pg 111] little richer in color than can be made with the disks of the color wheel. If we introduce a small amount of white into the brown of the material we may hope to match it with the disks and this may be done by cutting a bit of fairly heavy white paper in the form shown in the diagram and loosening the nut of the color wheel slightly, after which we insert the point of the triangle under the nut so that when tightened the white paper may be held in front of the brown disk, as in the illustration. Trim the outer end even with the disk and then rotate. If the effect of the white is too great trim off a little from the side of the white paper to make it narrower, until a perfect match is secured.

The small disk in rotation is then of the same color but not quite so intense as before, or in other words, is a very deep tint of the color. In this way the Nomenclature can be recorded as follows: Brown 95, W. 5, = R. 22, O. 16, N. 62.

This result does not often occur, but the subject is noticed here in detail that no one may be in doubt when such cases do come to light, as they will sooner or later.

The aniline colors give some purples which are much more brilliant than either the violet or red which otherwise should by combination produce them, so that with these standards they cannot be made, but must be reduced with white, or possibly with white and black.

If a color wheel is not available many of these experiments may be tried on the color top, but not as satisfactorily, because of the accuracy necessary in cutting so small a disk in a woven material. In using the top for analysis of all ordinary colors, the best plan is lay the material on a table or other level surface and spin the top on it. If quite an accurate test is desired the cardboard disk of the top may be trimmed down to the size of the largest paper disk, so that there will be no intervening ring of light color to separate the color of the rotating disks from the material on which it is spun.

Practical applications of the color top are already being made, as for example, in the selection of house furnishings. For this purpose disks of the top are combined at home to produce the desired colors to match the wood finishings and papers or draperies in a partially completed room, the top being used as a guide in preliminary selections of additional materials from the stores. [Pg 112]

If a number of colors are required it is convenient to use several combinations of disks, each set being slightly gummed together. In this way standards for various colors with a top spindle for rotation in the salesroom may be carried in a very small space.

The Bradley Colored Papers.

As every competent artisan must understand the use for which each implement is designed, in order to secure the best results with it, possibly a brief explanation of the principles on which the colors in the Bradley Educational Colored Papers are selected and classified may be of value. In the sample books of these colored papers there are four sections. The first section of the book, following the title leaf called "Pure Spectrum Scales" consists in part of the six standard colors, red, orange, yellow, green, blue and violet, with two intermediate hues between each two standards, which eighteen colors form the central vertical column in the Chart of Pure Spectrum Scales shown on Page 41.

In addition to these eighteen normal spectrum colors, there are two tints and two shades of each, thus producing eighteen spectrum scales of five tones, in which the normal colors as indicated in the central column aim to be the purest possible pigmentary expressions of the spectrum colors represented.

In determining the number of colors to adopt in the preparation of the papers enough have been selected to furnish types of all the colors in the spectrum, and also the hues between red and violet, but at the same time the number has been so restricted as to secure a reasonably simple nomenclature of the intermediate hues. [Pg 113] A hue of a color is defined as the result of the admixture of that color with a smaller quantity of another color; thus a hue of red approaching the orange is an orange hue of red, or an orange-red. If a small amount of red is added to orange the result is a red hue of orange, or a red-orange.

Therefore in selecting two hues between each two standards, rather than a larger number, the simplest nomenclature possible is secured, and one in which no mental effort is necessary to recall the color indicated by each symbol. For example, we have four colors indicated as R, OR, RO, O; red, orange-red, red-orange, orange; or more extended, red, orange hue of red, red hue of orange, orange. Thus by using as symbols familiar terms, no effort of the memory is required to recall the color indicated by each symbol, as would necessarily be the case if there were a greater number of hues and therefore more arbitrary symbols.

The use of rotating color disks on the wheel and the top by which an infinite variety of intermediate hues can be made and accurately named by the pupils reduces the required number of papers to those types necessary for first primary work, and thus prepares the child for the use of pigments at an earlier age than would be possible without such color instruction.

The second section of the sample book contains white, black and grays as indicated on the separating fly leaf. In these the best pigmentary expression of black and white are furnished. In material colors as found in industrial products, there are various so-called blacks and whites. For black there are blue-black, green-black, and brown-black; and in white, cream-white and pearl-white. Cream-white is a yellow-white and pearl-white a blue-white. In fine white papers either blue, red or yellow is generally added to the pulp to counteract or cover up the gray tone of the natural material. The standard black here presented is the best possible pigmentary imitation of a very deep black hole, as for example, the projecting end of a large iron water or sewer pipe of considerable length buried in the ground, which is the blackest thing known.

The white is an imitation of new-fallen snow. Neither of these standards can be very nearly approached although we often hear of things as "white as snow" and as "black as night." [Pg 114] In the same group and following the black and white are two examples each of the four kinds of grays: Green gray, warm gray, cool gray and neutral gray. A pure white in shadow is the true neutral gray and a perfect imitation of this is made by the rotation of combined black and white disks on the color wheel. If to the black and white disks we add a blue disk we have cool grays. With red, orange or yellow the warm grays are produced, while the use of a green disk gives green grays. In the papers two tones of each gray are furnished.

The papers found in the first two sections comprise all the colors necessary for earliest primary color instruction, and should become familiar to the children before explanation is made of the colors in the succeeding collections.

In the third section, designated "Broken Spectrum Scales" will be found a collection of gray colors or broken colors. As has before been stated, a broken color is a pure color mixed with a neutral gray. In the combination of pigmentary colors a tint of a color is the pure color mixed with white, a shade is the color mixed with black, and a broken color is a pure color mixed with both black and white, which is a neutral gray. Therefore if with red, for example, we mix a certain amount of a given neutral gray and call that the normal tone of a broken scale of red, for the tint in that scale we must mix with the standard red a lighter gray and for the shade a darker gray.

When a comparatively small quantity of neutral gray is combined with a pure color the result is a "gray color," as above described, because the color is quite definitely retained, but more or less modified by the gray. On the other hand, if a relatively small quantity of color is added to a neutral gray, the resulting color is properly called a "colored gray," because it is still a gray modified by color, and in this class we have warm grays, cool grays, etc., according to the color combined with the gray. The gray colors are quite generally termed "broken colors" and this [Pg 115] seems a very useful practice, because it avoids the confusion of the somewhat similar terms "gray color" and "colored gray."

By reference to the Chart of Broken Spectrum Scales on Page 41 it will be seen that we have only twelve scales and but three tones in each scale, instead of eighteen scales and five tones, as in the pure scales, for which there is a good reason.

For educational purposes in the elementary grades, which is the only place where there is a legitimate use for colored papers, the steps in gradation of hue or tone must not be too short, and if the saturation or intensity of the normal colors in the several scales is reduced by adding gray, as in the broken colors, there is not the possibility for as many steps in either hues or tones without leaving those colors adjacent to each other too nearly alike. Therefore in the broken colors there are but thirty-six, instead of ninety, as in the pure scales.

The distinction between pure colors with tints and shades, and broken colors in various tones, should be made very plain to the children whenever the subject is brought to their notice, because it is a vital point in the classification of colors. Educationally this is one of the most objectionable features in the old red, yellow and blue theory of color composition, because no distinction is observed between pure and broken colors in classification. In the Bradley colored papers the distinction is made very decided for educational purposes, so that no one would for a moment tolerate the mixture of the normal colors from the pure scales with the normal colors from the broken scales in the formation of a spectrum.

This may be illustrated by a selection as follows: First lay in order the normal spectrum colors with the pure colors found in the first section of the sample book, thereby forming the central vertical column of Fig. 10. Then substitute for the orange, green and violet, those colors selected from the collection of broken colors, and the result will seem to render the operation absurd, but [Pg 116] it is the same in principle as the results produced in the attempt to form a spectrum by the combination of three primary pigments, red, yellow and blue, because so produced the orange, green and violet, show by disk analysis from 54 to 80 per cent of black and white and are therefore as much broken as the corresponding colors in the papers of the broken scales, but not exactly the same in tone.

Engine Colored Papers.

Those papers which are termed "Engine Colored Papers" are so named from the process of manufacture as distinguished from "coated papers" which comprise the first three sections of the book. In coated papers a white paper is covered with a coating of colored pigment "fixed" with a small amount of white gum, gelatine or glue, and in this way the pure color of the pigment is obtained. In the engine colored papers the color is mixed with the paper pulp in the process of making the paper. In a paper mill the tub or vat in which the pulp is kept stirred up and perfectly mixed is called the engine, and hence this technical term has been applied to such papers as are colored in the pulp. In this class of papers both sides are alike, and for this reason in some of the folding exercises these papers are preferred, also because they are thinner and tougher. Heretofore, it has been impossible to obtain engine colored papers in "families" or scales, but in this assortment the numbers from one to six, furnish six scales of three tones each, comprising the normal tones with tints and shades. Following these from seven to sixteen are a collection of unclassified colors including grays which are much used. All these can be analyzed and classified by the color wheel. Black and white complete this class. It is impossible to make any close approximation to a black in this class of papers, as when they are compared with the coated blacks the result is a very gray black, or very dark gray. All the colors in these papers from No. 1 A to No. 13 are quite light broken spectrum colors, but less broken than the coated papers designated as broken spectrum colors.

[Pg 117] While great care has been bestowed on the original selection of the colors of all these above-described papers and every effort is constantly exercised to keep them the same from year to year, the subject is materially complicated by the guarantee required of the manufacturers that no arsenic colors shall be used in the preparation of any of the papers. This guarantee is strictly insisted on, because, while the writer has never been able to learn of any authentic case where a child has been injured by the use of plated or glazed papers, he believes that the opinions of parents and teachers should be respected in the matter, although the arsenic colors are often the most permanent and the aniline substitutes which are necessarily used belong to a class which is the most fugitive of all colors.

The line of colored papers now in use is the result of many experiments on the part of the writer and careful tests by experienced teachers for several years, and in its present condition affords but small indication of the time and care which has been expended on it. This has been inevitable, because the peculiar system on which the colors are based has been one of growth and the papers have been designed to afford the necessary material colors for this special scheme of instruction.

In preparing the tints and shades in the papers many experiments have been made to determine the true effect of light and shadow on each normal color, and then to imitate these effects in the papers.

All this is independent of the professional tricks which artists use to heighten their effects, some of which are legitimate, while others may be questionable on sound principles.

It is a common habit with artists to introduce very warm effects into all sunlight by the use of orange or yellow in the warm colors. This extreme tendency has been intentionally avoided in the preparation of these papers, however desirable or allowable it may be considered in heightening effects. So also in the shades as in the tints, the aim has been to keep all the tones of one color in the same scale, even though artists often run the various tones of the same piece of color into [Pg 118]
two or three analogous scales.

It is the object of color education to train the eye to see color wherever or however it may be produced, either by actual color reflection or contrasted effects, and in order that these effects may be understood as explained under Simultaneous Contrasts it is necessary that the prepared material be truthful to nature, the more so because these effects are sometimes greatly exaggerated by artists.

Water Colors.

When the subject of color was introduced into the curriculum of the common schools of this country, the use of paints was a novelty. So little was known regarding the possibilities of water colors as a means of education, that the teachers may be excused for having had grave doubts about the practicability of the scheme. Very few teachers in the lower grades of schools had received at that time any definite instruction in the harmonies of colors or the manipulation of pigments; and what little thought had been given to the subject was based on the three-color theory of Brewster, which was the only one available at that time.

During the intervening years much has been done to make entirely feasible the introduction into school and kindergarten of this pleasing and educating occupation.

Color standards have been adopted, which are nothing less than selections from the solar spectrum itself, and the manufacture of pigments has improved so much that it may almost be said to be a new industry. In the training of teachers, also, color instruction is now given an important place, so that the kindergartner and primary teacher can give the attention that it deserves to a subject which is so interwoven with all that is beautiful in the material world around us.

Passing from one form of color work to another, it is exceedingly important that children of any grade should find the same principles obtaining in each step of the way, and also that the [Pg 119]
knowledge gained in the earliest stages of the work should be available in the higher forms. This is particularly true of color instruction as it is now found in the best schools, and the principal reason why water colors are so much better adapted to use in the schools to-day than in former years, is because paints are now made to correspond in color with the standards with which the children have become familiar in the colored papers and other material of the kindergarten.

At present it is generally conceded that these six colors, Red, Orange, Yellow, Green, Blue and Violet, which stand out so prominently in the solar spectrum, are pre-eminently adapted to serve as standards and as the basis of an alphabet of color. There should, therefore, be no question as to the adoption of these same colors as the palette of paints for the earliest color work, even with the babes in the kindergarten, when anything beyond the colored papers and the usual kindergarten occupations is wanted.

Not very long ago it was the practice to give the child a box of colors and let him paint at random without any definite instruction as to the relation which each color should bear to the others. In fact, with the usual cheap box of paints then in the market there was no decided correlation of the colors nor any educational selection, both of which we have to-day.

Water colors are now furnished which so closely approach the standards of the colored papers that they are of the greatest assistance in developing the æsthetic taste and judgment of the pupils, and it is remarkable how early in the training of children paints can be used with advantage.

In some of the previous pages of this book we have treated of the false theory of Sir David Brewster, who supposed that there were three primary colors in the solar spectrum and that all the other colors were produced by the overlapping or mixing of these in pairs.

This error, being applied to pigments, has worked much harm and has greatly retarded the [Pg 120] progress of color study. Even now some teachers recommend the use of the red, yellow and blue palette on the ground of simplicity and economy.

All the recent scientific writers on color treat this three-color scheme as already exploded, because the simplest as well as the most complex experiments with colored light prove its falsity. Nevertheless, the fact that yellow and blue, which with light make very nearly white, do in the mixture of pigments produce a green, has deceived many persons. But the best green that can be so procured is a very broken color and not to be successfully compared with the beautiful and brilliant green of the spectrum. Why then, should we not have in our paints imitations of the solar green, orange and violet as well as the red, yellow and blue? It is not well to sacrifice so much for alleged simplicity, and as for economy, it will take but a moment's reflection to see that it would take no more paint to cover a given surface with six colors than with three.

Oil colors, of course, are out of the question and pastels almost equally so, for although full colors may be produced in both these mediums, they are not suited to the use of young children, and at best are neither neat nor convenient, while colored pencils are not sufficiently satisfactory in results. Therefore water colors seem to be better adapted to primary work than any other pigmentary material.

Of necessity the pupil must later be able to recognize any pigment he may meet and to classify it according to its color value and also to give it a definite name, other than the one by which it is sold.

More than one professional artist has already worked successfully from nature in oil colors with a palette consisting of only close approximations to the six standard colors with white and a few grays. A person whose color perception has been trained by the use of the color disk in six standard colors with colored papers to correspond, will undoubtedly be able to more truthfully [Pg 121] reproduce the colors which he sees in nature, on the canvas or paper by means of such a pallette than if he had been taught by any other system and used the ordinary pigments.

Color Blindness.

The subject of color blindness has received much attention because of its practical importance in the affairs of our daily lives. The use of colored lights as signals on ships and railroads has necessitated very strict regulations regarding the employment of persons whose color vision is defective, and therefore in some states specialists have been employed by the state authorities to examine from time to time the school children regarding their perception of colors.

Possibly this condition of things may not at present be considered a serious reflection on the methods of color instruction, or lack of such instruction in our schools because it has become so common as to attract little attention. But if it were necessary for the same course to be pursued in any other department of our public education that fact would not fail to occasion very uncomplimentary remarks regarding the methods employed.

For example, if a state official were necessary to determine whether pupils are deaf or not after they have been through our grammar schools, and preliminary to accepting positions of responsibility, it would seem that something was wrong, and yet after a child has had instruction in color according to a logical system there should be no more necessity for an examination regarding his ability to properly distinguish colors than there should regarding his ability to hear.

Color blindness has quite generally been divided into three classes, red, green, and violet blindness, those afflicted with red blindness being most numerous, and the cases of violet blindness being very rare, if indeed there are any which may properly be so called.

This classification, known as the Holmgren system, seems to have been based on the Young-Helmholtz theory that all color perceptions are the result of three primary effects in the eye, [Pg 122] namely, red, green and violet, rather than on any analytical classification of actual experiments concerning color blindness.

Color tests should be so arranged as to detect either a defect in the brain which renders it difficult for the pupil to remember the names of the several colors, or in the eye, by which he cannot see a difference between two dissimilar colors.

A person totally color blind would see in the solar spectrum a band of gray in various tones, and hence if a red and a green should seem to be of the same tone of gray he would call both either red or green, and after much experience would come to give color names to various tones of gray.

Such cases, however, are exceedingly rare, if in fact they exist. Other scientists and physiologists have doubted the truth of the claims made by both Holmgren and Helmholtz, and some have made extended experiments regarding color blindness which seem to oppose the Holmgren theory. In view of these conditions it does not seem necessary for a teacher in the elementary grades to attempt to grasp the situation very fully, and much less to aid in the solution of the problem. Very fortunately this is unnecessary, because in all the scientific tests proposed for adults nothing is accomplished which any primary school teacher will not be easily able to determine during the first two or three years of ordinary school work, if the modern system of color instruction is pursued.

There is no better material than colored papers for testing the color perceptions, and the exercises of selecting, matching and arranging the spectrum colors by means of the small color tablets generally in use in the first years of school are the very best that can be devised without regard to any of the abstract theories concerning either the cause or the possible classification of color blindness.

For some reason the most common form of color blindness occasions a confusion between red and green, as for example, we are told, by some people, that in picking wild strawberries in a field the fruit can be distinguished from the leaves and grass only by the shape, and the green fruit from the ripe by the touch or taste.

If a teacher discovers that a child is unable to readily give the name of a color it may not indicate want of color vision, but merely inability to remember names, and therefore various tests which will naturally suggest themselves can be made to aid in reaching a decision on this point. Should the results of the tests seem to indicate some defect in color vision, the nature of the trouble should be sought and memoranda made from time to time for future reference, and if the final result shows a radical lack of color perception the parents should be informed of the fact and a physician consulted.

It is probable that the number of color blind women is very much less than that of men, and much time has been spent in debating the matter, but some doubt remains as to whether this opinion does not obtain because the girls are brought so much more intimately into relation with colored materials in selecting their articles of dress, and consequently come to know the names of colors much better, and in fact enjoy a much better color education than the men. A more correct decision regarding this question can better be reached when both the boys and girls receive a systematic color education and their color sense is more equally cultivated.

Outline of a Course in Color Instruction.

THE course of color instruction suggested in the preceding pages is not arbitrarily divided into lessons or even years, because the conditions in the city and rural schools in the various states of this country are so varied that no uniform allotment or division of time can be suggested which will be satisfactory to all.

The number of hours that can be devoted to any subject must be determined by those who prepare the school programme and the progress must be more or less rapid, with instruction correspondingly superficial or complete at each stage, according to the time allowed, the preparation of the teacher and the natural ability of the pupils.

The teaching of color is usually classed with drawing because both relate directly to art, but inasmuch as color enters into our every day experiences so much more largely than the graphic arts there seems to be good reason for teaching it very fully where little attention is given to drawing.

Every competent teacher can and will become expert and even enthusiastic in teaching color, if she fully understands the system which it is the object of the foregoing pages to explain.

The following brief outline suggests the order in which the facts concerning color may be presented and the material which can be used in an elementary course, beginning with the first primary grade pupils, who for the most part have not had kindergarten training.

As a part of the material the Bradley Educational Colored Papers, cut to tablets each 1 x 2 inches, are prepared and put up in four small envelopes which are enclosed in one larger envelope. On the larger envelope these words are printed: "The Bradley Paper Tablets for Primary Color Education, Selections 1, 2, 3, 4 for Complete Course." The four small envelopes are labeled in this way: "Selection No. 1, eighteen pieces from Chart of Pure Spectrum Scales, the Normal Spectrum Colors." "Selection No. 2, forty pieces from Chart of Pure Spectrum Scales, Tint No. 1 and Shades No. 1, with White, Black and Neutral Grays." "Selection No. 3, forty-two pieces comprising complete Chart of Broken Spectrum Scales and Warm, Cool and Green Grays." "Selection No. 4, thirty-six pieces from Chart of Pure Spectrum Scales, Tints No. 2 and Shades No. 2."

The Solar Spectrum.

MATERIAL.

A Glass Prism, the cost of which need not exceed a few cents, as almost any lamp or gas pendent in the form of a prism will serve the purpose. By the use of such a prism a small spectrum can be shown on the wall of any schoolroom having a sunny exposure during any part of the day. This spectrum will make plain the fact that sunlight is composed of many colors.

METHOD.

Show to the pupils the best solar spectrum that can be produced under the controlling conditions.

Call attention to the six colors, red, orange, yellow, green, blue and violet, and the order of their arrangement in the spectrum.

Present the colors separately as far as possible, selecting the best conditions available for each one.

Pigmentary Spectrum Colors.

MATERIAL.

Neutral gray or white card to cover desk top for a background.

Chart of Pure Spectrum Scales.

Colored Paper Tablets, Selection No. 1, embracing the six standards and the intermediate spectrum hues, eighteen pieces.

Color Wheel or Tops.

METHOD.

Ask the pupils to separate the six standards from the twelve spectrum hues. Standards to be arranged in spectrum order.

Teach the names of the standards.

Test natural color perceptions by the attempts of the pupils to lay the spectrum in the eighteen papers.

Explain the intermediate hues by the color disks, and drill with the tablets. Continue the practice of having the pupils lay the entire spectrum with the papers until it is familiar to them.

PRACTICAL OCCUPATIONS.

Pasting simple designs in either of the six standard colors, on white or gray background, with ready-cut papers. Marking forms from tablets and cutting and pasting them on backgrounds.

Study of Tones.

MATERIAL.

Folding models to show light and shade. Crumpled satins and plushes.

Standard color disks with white and black, on wheel or tops.

Paper tablets, Selection No. 2, Tints No. 1, Shades No. 1, White, Black and Neutral Grays.

METHOD.

Ask each pupil to lay spectrum in eighteen normal colors. Lay tints and shades of the six standards.

Have the children complete tints and shades No. 1 of entire spectrum circuit.

Illustrate neutral grays by white in shadow with folding model, also with white and black disks combined.

Begin to classify into families the miscellaneous color material brought by the pupils.

PRACTICAL OCCUPATIONS.

Pasting of ready-cut papers in standard and shade on a background of the tint of same scale.

Paste designs in three tones of one scale on white or neutral gray background.

Mat weaving in tones of one scale.

Mat weaving in neutral gray and one or two tones of one color.

Broken Colors.

MATERIAL.

Disks on wheel or top. Paper tablets, Selection No. 3. Chart of Broken Spectrum Scales.

METHOD.

Illustrate broken colors by disk combinations.

Let the pupils lay paper tablets to form Chart of Broken Scales.

Compare this chart with the Chart of Pure Scales laid with the papers.

Classifying of miscellaneous materials with reference to pure and broken colors. Analysis of samples of pure and broken colors in cloths and flowers.

PRACTICAL OCCUPATIONS.

Paper cutting and pasting to be continued.

Following the broken colors in three tones which form the Chart of Broken Spectrum Colors, the three kinds of colored grays, warm, cool and green, may be considered preparatory to their use in contrasted effects.

Complete Chart of Pure Spectrum Scales in Five Tones.

MATERIAL.

Paper tablets, Selection No. 4. Chart of Spectrum Scales in five tones may be introduced for observation when the children are able to lay it with their papers.

METHOD.

Continue the study of tones with pure spectrum scales in five tones, as was done in the first three tones.

From the Chart of Spectrum Scales the study and classification of harmonies can begin in a simple way.

From this time on free-hand paper cutting and pasting may be introduced at pleasure, employing the colored papers in five tones when required.

Advanced Study of Harmonies.

By taking advantage of the instruction imparted in a course of color study such as has been outlined in the preceding pages the pupil will be able to advance in his ability to perceive colors and to make definite analyses of colors in natural and manufactured material. In this way the advanced study of harmonies can be greatly facilitated so that it will be possible for the student to apprehend and appreciate many delicate and subtle color effects in art and nature never before imagined. In fact the foundation of color study will have been laid in such a logical and fascinating manner that its further advance will be but a pleasure to the pupil and teacher, so that no arbitrary plan will be necessary, because so many lines of work will suggest themselves to all who are interested in the subject.

Water Colors.

This outline would not be complete without a reference to water colors, but this is not the place to give definite instructions as to their use. Kindergartners and primary teachers are now generally competent to direct the children in this work, if they will avail themselves of such aid as is furnished by recently published books on the subject.

Non-poisonous paints, cheap and still of fair quality, can now be obtained in standard colors and put up in various forms. The moist paints in collapsible tubes are the most convenient as well as the most economical for school use. This form should be accompanied by a small mixing palette containing several compartments, which can be bought at so small a price that each pupil can have one. The paint in the tubes can then be dealt out only as required for each day's use.

MATERIAL FOR COLOR INSTRUCTION.

Where the price is preceded by a star the article is too large to be sent by mail. In other cases where no postage is given the goods are sent postpaid on receipt of price.

WATER COLORS.

In ordering it will be necessary to give only the number of the box.

No.		Price.	Postage.

1. An enameled box containing eight pans of semi-moist colors, six Standards and two Grays, one brush, per box	$ .35	
2. An enameled box containing ten pans semi-moist colors, six Standards, Black, White, Cool Gray and Warm Gray, one brush, per box	.50	
3. Same box as above, containing five pans semi-moist colors. Red, two Yellows, Blue and Gray, one brush, per box	.30	
4. Enameled box containing four pans semi-moist colors, Red, Yellow, Blue and Gray, one brush, per box	.20	
5. Same as above, Red, two Yellows and Blue, per box	.20	
6. A decorated box containing eight cakes of dry colors, six Standards and two Grays, one brush, per box	.25	
7. A decorated box containing four large cakes of dry colors. Red, Yellow, Blue and Gray, one brush, per box	.20	
8. Same box as above. Red, two Yellows and Blue, two brushes, per box	.20	
9. Nine tubes moist colors in strong paper box. Six Standards, Warm Gray, Cool Gray and Black, per set	.90	
10. Photograph Colors. A box of eight colors, the six Standards and a Chinese White and a Brown, with one brush. These colors are expressly prepared for coloring photographs, half tone prints, maps, etc.	.25	
Bradley's School Colors, moist in Tubes. The most economical form for school use. These colors are so prepared that they remain moist out of the tube. The set comprises the following colors: Carmine, Crimson Lake, Vermilion, Gamboge, Chinese Yellow, Hooker's Green, No. I, Hooker's Green, No. II, Ultramarine, Prussian Blue, Sepia, Warm Sepia, Burnt Sienna, Payne's Gray, Ivory Black, Chinese White and the six Standards, with Warm, Cool and Neutral Gray, Black and White, per tube	.10	[Pg 130]
Little Artist's Complete Outfit, comprising a Mixing Palette with its seven compartments filled with semi-moist colors and a brush, the whole enclosed in a strong cardboard case	.15	.03

ACCESSORIES

Standard Mixing Palette, with seven compartments for paints and two for mixing. Almost indispensable in using tube colors. Extra deep, per doz.	.60	.25
Water Cups. An enameled metal cup, practically indestructible, per doz.	.60	.13
Camel's Hair Brushes, Quill, per doz.	.30	.02
Camel's Hair Brushes, Long Handles, per doz.	.60	.03
Japanese School Brushes, per doz.	.60	.05
Artists' Camel Hair Brushes, No. 6, Wooden Handles, per doz.	.75	.03
Milton Bradley Co.'s Water Color Pads—Made of extra quality paper for water color work.		
No. 1, Pad of 50 sheets, 6x9, each	.10	.09
No. 2, Pad of 25 sheets, 9x12, each	.10	.10

APPARATUS

High School Color Wheel, with Disks in box	*10.00	
One set of Disks for above, in box	*2.00	
Primary School Color Wheel, with Disks	*3.00	
One set of Disks for above in portfolio	.75	.06
Color Top, by mail, each	.06	
Color Top, by mail, per doz.	.50	
No. 1 Prism, at buyer's risk	.10	
No. 2 Prism, at buyer's risk	.15	

No. 3 Prism, at buyer's risk	.30	
Rainy Day Spectrum, made from colored papers, mounted on cardboard, 1" x 13", each	.10	.04
Large Spectrum, 5" x 30", mounted on cloth, each	.25	.04
Chart of Pure Spectrum Scales, No. 1 X, on cardboard, 9" x 24", hinged and folded. Ninety papers one inch square, each	.50	.10
Chart of Pure Spectrum Scales, No. 2 X. Size, 12"x48", folded and hinged. Ninety papers two inches square, each	.75	.15
Chart of Broken Spectrum Scales, No. 1. Size, 9"x12", with paper 1-1/2 inches square, comprising twelve scales of three tones each	.50	.10
Chart of Broken Spectrum Scales, No. 2. Size, 12"x48", with the same papers as No. 1, three inches square, each	.75	.15
Chart of Complementary Colors. On cardboard 18 inches square, each	*.50	
Standard Color Chart. On two cards 11x28 inches, hinged and eyeleted for hanging. This is a combination chart comprising "Spectrum Standards," "Pure Spectrum Scales," "Complementary Contrasts," "Broken Spectrum Scales," and "Grays." Printed suggestions for using the charts on the back, each	1.25	.15

BOOKS ON COLOR.

Water Colors in the Schoolroom, by Milton Bradley, boards	.25	
A new book of practical suggestions, valuable to every one who would undertake to teach the use of water colors.		
Elementary color, by Milton Bradley, cloth	.75	
Gives the principles on which the Bradley System is based and an explanation of the use of the Glass Prism, Color Wheel, Maxwell Disks, Color Top, Colored Papers, Color Charts and Water Colors.		
The Little Artist by Marion Mackenzie, cloth	.75	.15
A practical book of water color work for children, with 12 beautiful, colored plates. Size of book, 12x14 inches.		
Color in the Kindergarten, by Milton Bradley, paper covers	.25	
A manual of the theory of color and the use of color material in the Kindergarten.		
A Class Book of Color, by Prof. Mark M. Maycock. Teachers' Edition, cloth	1.00	
Pupils' Edition, boards	.50	
A very complete teachers' handbook in color.		
Practical Color Work, by Helena P. Chace, paper	.25	
A handbook for the educational use of colored papers in teaching color in primary and ungraded schools.		
The Color Primer, by Milton Bradley, paper. Teachers' Edition, 80 pages	.10	
Pupils' Edition, 24 pages	.05	
Simple and direct teachings.		

MISCELLANEOUS MATERIAL.

Paper Tablets, Set No. 1, 1x2 in.	.02	
Paper Tablets, Set No. 2, 1x2 in.	.02	
Paper Tablets, Set No. 3, 1x2 in.	.03	
Paper Tablets, Set No. 4, 1x2 in.	.04	
Sample Book, one by four inches, containing the full assortment	.05	.01
Package, 4x4 papers, 100 pieces	.20	.04
Package, 5x5 papers, 100 pieces	.30	.05

Fun, Physics and Psychology in Color. A box of material for simple experiment, each	.25 .07
Complementary Color Contrasts. A box of large material for popular experiments in color vision, each	.75 .20
The Dunn and Curtis Illustrative Sewing Cards, in color. Two sets: A. Literature Illustration. B. Cards for Special Occasions.	
Set of eight cards	.25
Dozen of any Design	.40

MILTON BRADLEY COMPANY,

Springfield, Mass.

Footnotes:

[A] The Principles of Harmony and Contrasts of Colours and their Application to the Arts. By M. E. Chevreul. Translated from the French by Charles Martel. Third Edition. London. George Bell and Sons. 1890.

[B] The Theory of Color in its relation to Art and Art Industry. By Dr. William Von Bezold. Translated from the German by S. K. Koehler with introduction and notes by Edward C. Pickering. Boston; L. Prang & Company, 1876.

[C] Tablets of paper instead of cardboard are recommended because in primary instruction the standards or types of color presented to the child ought to be the purest possible expressions of the colors represented, and a piece of color material cannot meet this requirement after having been used one year by a child. The necessary expense of cardboard tablets practically precludes a new supply each year. But the papers can finally be used to form, by pasting, some chart or combination which the pupil may be allowed to own as a sample of his work.

[D] A Nomenclature of Colors for Naturalists and Compendium of useful Knowledge for Ornithologists by Robert Ridgway, Curator, Department of Birds, National Museum. Boston, Little, Brown & Co., 1886.

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