

A MECHANICAL COLOR TEST.

BY MARCUS BENJAMIN, PH.D.

Early in 1894, the question of the possibility of analyzing various colors and shades in terms of certain standards having been referred to the present writer, he sought the advice of Professor Thomas C. Mendenhall and Professor John K. Rees, of the American Metrological Society, concerning the feasibility of appointing a committee to fix such standards. This action resulted in the naming of a committee, and, what has since proved of much importance, the taking up of the entire matter as a special investigation by the Physical Department of Columbia College, under the immediate supervision of Professor William Hallock and Mr. Reginald Gordon.

At the outset it must be stated that the important, the vital, element in any color system is the employment of proper standards. Physicists here and elsewhere have from time to time studied this subject and have determined standards, but it has remained for Professor Hallock to introduce practical standards that are easily procurable and readily determined. For this purpose he carefully sought out five typical colors from among the many pigments on sale in the open market. His selection was as follows: Best English vermilion, mineral orange, light chrome yellow, emerald green, and artificial ultramarine blue. Having chosen the fundamental standards, it became necessary to identify them exactly in the spectrum by means of the instrument known as a spectroscope and in terms of wave lengths of light.

As soon as the selection of the typical pigments was made, it became necessary to say exactly what they were in terms referable to the solar spectrum, and for this purpose the use of the spectroscope was essential. Prof. Hallock found his colors to have the following values expressed in microns: Red, 0.644; orange, 0.614; yellow, 0.585; green, 0.521; blue, 0.425. Thus the green 0.521 corresponds to the b line and the orange 0.585 is very close to the D line, which is the characteristic element in the spectrum of sodium.

The important elements of luminosity and saturation require some consideration. We find that a color changes in value according to the degree of its illumination. That is under certain conditions of light the color is stronger or more intense than under certain other conditions. This effect may be artificially produced by the addition of black. So likewise color reflects to the eye a greater or less proportion of the white light that it contains. Hence by the use of black and white in addition to the standard colors selected, the further consideration of these elements may be eliminated.

With the five colors, and black and white, it is now possible to determine exactly in terms of the standards the composition of any shade or hue in existence. But how? This constitutes the second portion of the investigation. We have made our tools, and now to use them.

Sir Isaac Newton was the first to point out that white was decomposed into the so-called spectrum colors, and his name has also attached itself to an apparatus in circular form, on which are arranged disks of colored paper representing the spectrum colors. When this disk is rapidly rotated, the colors, so to speak, decompose themselves, forming a more or less white or gray. J. Clark Maxwell, an English physicist of recent date, perfected a similar instrument known as a color wheel. For the purpose of the investigation this instrument was used and seven disks were employed. They were about five inches in diameter, with a small hole at the center for the axis and a radial cut from the center to the periphery.

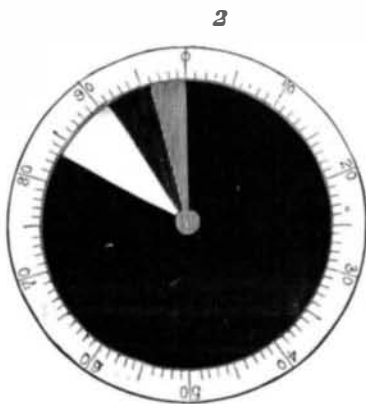
The white disk was of the purest white cardboard; the others were cut from light cardboard or heavy drawing paper, and painted each with its proper pigment, first mixed with a thick solution of gum Arabic in water to the consistency of oil paint, and then applied with a bristle brush. The color must be

even and the paper completely covered. For the black disk a mixture of the best lamp black in an alcoholic solution of shellac was used and similarly applied with a bristle brush. A disk slightly larger than the foregoing, with a circular scale made by dividing it into exactly one hundred parts is also necessary. In use the colored disks are combined by overlapping each other until approximately the desired shade or tint is made, and then rapidly rotated until the different disks produce on the eye the effect of a single mass of color. The scale records the exact proportion of each used. Thus, for instance, the color known as cadmium orange is produced by using 65 parts of orange and 35 parts of yellow. Most colors, however, require the addition of either white or black. Hence we find the color fuchsia consists of 27 parts of red, 12 parts of blue, and 61 parts black. While, on the other hand, pearl blue consists of 22 parts green, 29 parts of blue, and 49 parts of white. Some shades require both black and white; thus mouse color consists of 5 parts blue, 14 parts white and 81 parts black. By means, therefore, of the wheel and standard disks it is possible to determine the composition of any color.

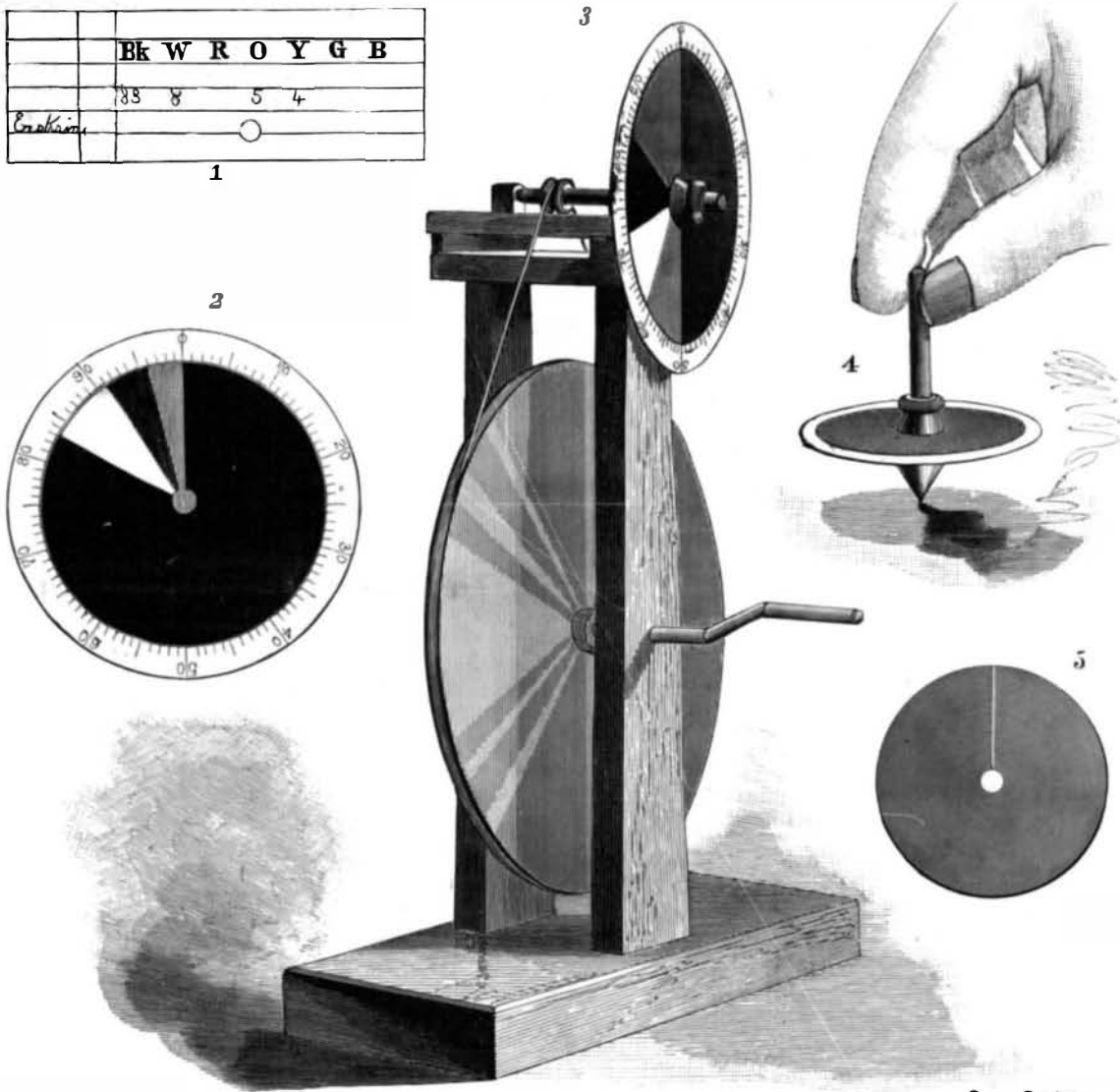
The investigation thus begun was to be developed into a system. It was decided to attempt the determination within reasonable limits of the composition of the many colors, shades and hues on the market.

	Bk	W	R	O	Y	G	B
	83	8		5	4		

1



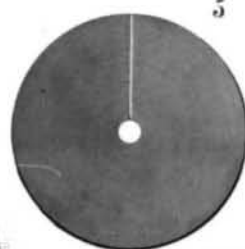
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3



4



5

1. Order card and formula. 2. Wheel and color disks. 3. The complete apparatus. 4. Experimental top. 5. Color disk.

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Thus, for instance, what is the composition of the once popular color known as crushed strawberry? For this purpose over 6,000 named samples of colored articles were collected from various sources all over the United States. These included about 3,500 silk threads, ribbons, plushes and other silk fabrics; 1,300 printed specimens of colored inks used in printing; 300 samples of colored woollens and cottons and some 400 paints, stains, pigments, etc. From these all the different specimens named "crushed strawberry" by their respective manufacturers or dealers were collected together and an analysis of each was made. From the results a formula for a color approximating to that which agreed to the average was deduced. To be specific, it consisted of 32 parts black, 24 parts red, 26 parts orange and 18 parts blue. Out of this collection of samples there has been prepared a table giving the exact composition of more than 500 colors, beginning with absinthe and ending with zulu.

In the actual manipulation Professor Hallock and Mr. Gordon were soon able to form an approximate idea of the composition of the color to be analyzed, so that the disks of its component colors could at least be immediately placed on the wheel, and then it was only necessary to adjust them in order to secure the result. The wheel was connected with a small dynamo, so that rapid rotation was made easy. In comparing colors, they held a sort of a mask in front of their eyes, so as to hide everything except the sample to be analyzed

and the mass on the wheel. The results obtained by them are easily within practical limits, that is to say, if the proportions given by them are recomposed on the wheel, the result will match the sample so closely that the ordinary person cannot detect a difference.

This investigation is of the utmost practical value to the community. For the first time it fixes with exactness the composition of most known colors. For a long time the nomenclature has been very confusing. Amber, Hayana brown, mazarine blue, and sea green give some suggestion of what they are like by their names, but such colors as Admiral, Charles X, luciole, and Pullman car, are not readily appreciable. If, however, the composition of Admiral is given as 13 parts of green, 37 parts of blue and 50 parts of black, we can see at a glance that the color is of a dark greenish blue. So likewise when the composition of Pullman car is said to be 86 parts of black, 4 of yellow, 5 of orange, and 5 of green, it is apparent that it is dark greenish yellow.

Turning to another phase of its utility, let us assume that we desire to match a piece of wall paper of the shade known as Pompeian red, of which we have a sample on hand. In order that the match shall be exact, we analyze the sample, and find it to consist of 89 parts black, 5 parts red, and 6 parts orange. Accordingly, our order should demand a paper that will agree with the foregoing composition. Besides wall papers, various fabrics can be easily duplicated by this process. Samples of cloth used in bookbinding can be matched with an exactness far beyond the usual commercial practice.

Other applications demonstrating the great practical value of this investigation will readily suggest themselves to the reader. The whole system is clearly represented in the accompanying engraving. In the apparatus shown the disk may be rotated by hand, and the same results are obtained as if it were rotated by an electric motor, as a variation in the rate of rotation does not produce a difference in the shade, but the colors blend in the same manner and degree irrespective of the speed. At the left is shown the graduated wheel and the superimposed colored disks. A voucher or order card is also given showing the manner of writing out the formula. The colored disk should be slit, so that the degree of color to be exposed to view may be varied according to the exigencies of the case.

An ordinary top may be used for purposes of experiment, and the various colored disks may be readily adjusted and clamped in position by means of a thumbscrew. Should such a system be brought into general use, it would result in the greatest advantage in the arts and would avoid the present confusion and uncertainty. Not only so, but with a constant and generally recognized standard, a color record could be preserved which would be of standard value for all countries and all ages, and colors could be read in the same value by succeeding generations as by those of the present day.

Our Lighthouses.

The lighthouses of the world number more than 7,000. The United States has over 1,300 houses and as many posts. The latter are simpler in construction and not very expensive, since they are maintained on shore. Our government has been proceeding with the theory that the coast should be so sprinkled with lights that the rays meet and pass; that a vessel will meet the one in advance before the one in the rear is out of sight. The annual appropriation for their keeping is now nearly \$4,000,000.

Kerosene oil is that which has been adopted by the lighthouse board as the luminant, though gas and, to a limited extent, electricity have been given a trial. Gas is being used only at Alexandria, Va., and Newburyport, Mass. Kerosene is considered the best and the cheapest. It is ever reliable. Electricity will no doubt be adopted when Congress can be prevailed upon to appropriate money.

What is Electricity?

In view of the number of theories advanced in answer to this question, the question might perhaps appear somewhat superfluous when so many satisfactory solutions—all more or less different—are at hand. In his concluding lecture at the Royal Institution, however, Professor Fleming answered it once more as follows:

What (said Professor Fleming) is this mysterious agent which we call electricity, and which seems so ready to adapt itself to our needs? It was the first question people asked; it was the last to be answered. Our knowledge of electricity was comparable to our knowledge of biology, or any other of the sciences. We could see the life processes at work, but were no nearer understanding what life was. We could see electricity at work, but failed to perceive what the thing itself was. However, science was beginning to recognize one thing as the result of its researches, and that was that electricity was probably a wave disturbance of the ether analogous to the wave disturbances which we called light. With light we had waves of the imponderable, ethereal medium which filled all space (equally that filling up space between the stars as that between the smallest atoms of matter) vibrating at the astounding speed of forty-five millions of millions per second, with an amplitude of oscillation as minute as the 37,030th of an inch. The researches of Faraday, Clerk-Maxwell, and Hertz had led to the demonstration by actual experiment that electricity was also a wave motion of the ether of great rapidity, but with waves yards in length instead of mere fractions, like those of light. It was in this direction that the great discoveries of the future would be made.

The Pratt Institute Plumbing Class.

The benefit of trade schools is well illustrated by the observation of a correspondent of the Sanitary Plumber: A few evenings since I called at the Pratt Institute, Brooklyn, and was very kindly shown through the plumbing class departments. The instructors, Messrs. George Heath and John Todd, are thoroughly conversant with both the theory and practice of plumbing and ventilation, and the classes under their charge are making unusually good progress this season. As I glanced down the line of boys, each with his complement of tools, pot, gas furnace, etc., working away under the bright light, I could hardly suppress a wish that I was a boy again simply for the privilege of learning the trade under such favorable conditions. Memories flitted through my mind of the times when, with a few odd wiping tools, a scrap of pipe and a broken-eared pot, I relegated myself to the basement or wood shed to practice wiping joints, so that no one would see my failures or smile at the antics I went through when I burned myself.

As the instructor stooped to direct and encourage one of the students whose solder was dripping from the bottom of the joint he was trying to make, I reflected upon the cold indifference of some journeymen I was obliged to work with when an apprentice. They seemed to take no notice of a boy until he succeeded in making a passable joint, and then, instead of taking the cloth and ladle and showing him how to improve or indicate where he had failed in that particular style of joint, they would invariably wipe another kind, in some difficult position, and while putting the finishing touches on, remark, "When you can do that, you will be a plumber."

During one hour of the session of Wednesday evening of each week Mr. Todd lectures to the boys on the elementary principles of the trade. The entire class attends this lecture, but it is especially intended for the junior class, while on Friday evening the senior class alone listen to an explanation of the more complex questions, which their better knowledge of the business aids them in appreciating. Both lectures are illustrated by diagrams. After a student has become proficient in a certain branch of work he is allowed to finish an example of it and fasten it to the wall above his bench, as evidence of the progress he is making. This serves to stimulate the boys to greater effort, because none of them is satisfied to see their fellow students get ahead if it can be prevented.

A Collection of Brains.

Dr. Luys has offered to the Paris faculty of medicine, for the Dupuytren Museum, a collection of 220 brains, carefully prepared and catalogued by him during his long service at the Salpêtrière and Charité Hospitals. In a letter to M. Brouardel, in which he calls his collection unparalleled in Europe, he describes in detail its scientific interest. "It presents," he says, "manifest samples of lesions of human brains, from the commonest ordinary hemiplegy, the aphasia, up to the most characteristic lesions of madness, and, as a foundation for the studies, hitherto so ill-based, of mental pathology, a series of types of persons suffering from hallucination or monomania, and of those who are chronically delirious with or without consciousness; and it presents also anatomical expressions in harmony with the symptoms observed. Types, of which there are four examples, relate to periodic madness. These

are the first examples of the sort ever collected and offered to the examination of the medical public, and they show similar lesions which justly place them in a special nosologic category. Next come brains of general paralytics, with granulated lesions in certain regions and characteristic concomitant atrophy. I have collected also a number of brains relating to idiocy, some relating also to deafness and deaf-mutes. Others have been taken from persons blind of one eye, from the wholly blind, and from the amputated, and they all show special atrophic lesions. There are chosen specimens, to which I intend later on to add others (in particular the brain of a hypnotized subject, the only one at present in existence), and they allow us from the point of view of the morphology of human brains to gain a rapid and accurate idea of the rarity or the frequency of such anatomic dispositions, since it is thus possible to consult immediately from the point of view of verification the cerebral lobes which are present under the eyes." The collection is the result of twenty years' investigation, and Dr. Luys looks upon it as his scientific heritage, "a stone" in the edifice of neurologic studies, which are assuredly in our day a glory of French science.—Paris Correspondence London Times.

THE BORING WOODPECKER.

The drawing shows part of a cedar telegraph pole from near Phoenix, Oregon,



TELEGRAPH POLE
BORED BY THE
WOODPECKER.

which has been bored full of holes by woodpeckers for the purpose of storing away acorns for their winter's supply. The birds generally use large pine trees for this purpose, but they have discovered that occasionally a telegraph pole serves their purpose admirably, as the drawing shows. The woodpecker first digs a hole in the pole about large enough for an acorn to fit in, then he flies off and soon returns with an acorn which he jams into the hole. He hammers away at it with his bill until only the head of the acorn is visible. So tightly are these acorns driven in, that they are with the greatest difficulty extracted. In such numbers do they store them that the bark of a large pine forty or fifty feet high will present the appearance of being studded with brass nails. The birds also store acorns in the hollow stalks of dead plants, notably the century plant, the flowering stalk of which is often found completely filled with the acorns. Sometimes the oak trees are thirty miles away from the birds' place of storage, so that the storing and collecting of each acorn requires a flight of sixty miles.

In times of famine all this good work shows to advantage, for not only birds but many kinds of beasts feed upon the acorns which the woodpeckers have so carefully hoarded. If it were not for the industry of the woodpeckers, they would have to die of starvation.

What People Will Eat a Century Hence.

According to Professor Berthelot, the distinguished French chemist, the time may be approaching when the farmer will go out of business, and bread and beef and milk, or their equivalents, will be produced artificially in the laboratory of the chemist. It is true that we have not yet got beyond the first steps in the process, but, according to Professor Berthelot, who is entitled to speak with authority, these first steps are a guarantee of extended triumphs in the same field.

The professor, as reported by Henry J. W. Dam, in McClure's Magazine, said that "new sources of mechanical energy would largely replace the present use of coal, and that a great proportion of our staple foods which we now obtain by natural growth would be manufactured direct, through the advance of synthetic chemistry, from their constituent elements, carbon, hydrogen, oxygen, and nitrogen." He continued: "I not only believe this, but I am unable to doubt it. The tendency of our present progress is along an easily discerned line, and can lead to only one end. I do not say that we shall give you artificial beefsteaks at once, nor do I say that we shall ever give you the beefsteak as we now obtain and cook it. We shall give you the

same identical food, however, chemically, digestively, and nutritively speaking. Its form will differ, because it will probably be a tablet. But it will be a tablet of any color and shape that is desired, and will, I think, entirely satisfy the epicurean senses of the future; for you must remember that the beefsteak of to-day is not the most perfect of pictures either in color or composition. There is a distinction which I would like to make at this point between the laboratory stage and the commercial stage of any given discovery in food making. From the scientific point of view, the laboratory result is the important one. As you and all the world know, the commercial result follows inevitably in time. Once science has declared that a desired end is attainable, the genius of invention fastens upon the problem, and the commercial production of the result slowly attains perfection by gradually improved processes at less and less cost. Take aluminum for instance. Once a very expensive metal, its steadily decreased cost in production is bringing it within the reach of all. The use of sugar is universal. Sugars have recently been made in the laboratory. Commerce has now taken up the question, and I see that an invention has recently been patented by which sugar is to be made upon a commercial scale from two gases, at something like one cent per pound. As to whether or not the gentlemen who own the process can do what the inventor claims, it is neither my province nor my desire to express an opinion."

The professor here cited as an instance of laboratory products, the dye stuff alizarin, the coloring principle of madder, which was formerly a great agricultural industry, but which is now almost wholly supplanted by the artificial product from coal tar. The chemists, he said, have succeeded also in making indigo direct from its elements, and artificial indigo will soon be a commercial product. "Tea and coffee could now be made artificially, if the necessity should arise, or if the commercial opportunity, through the necessary supplementary mechanical inventions, had been reached. The essential principle of both tea and coffee is the same. The difference of name between them and caffeine has arisen from the sources from which they were obtained. They are chemically identical in constitution, and their essence has often been made synthetically. The penultimate stage in the synthesis is theo-bromine, the essential principle of cocoa. Thus, you see, synthetic chemistry is getting ready to furnish from its laboratories the three great non-alcoholic beverages in general use. And what is true of food substances is equally applicable to all other organic substances."

As regards tobacco the professor said: "The essential principle of tobacco is nicotine. We have obtained pure nicotine, whose chemical constitution is perfectly understood, by treating salomon, a natural glucosid, with hydrogen. Synthetic chemistry has not made nicotine directly as yet, but it has very nearly reached it, and the laboratory manufacture of nicotine may be expected at any moment. . . . The tobacco leaf is simply so much dried vegetable matter in which nicotine is naturally stored. . . . Perhaps the greatest importance, and certainly the profoundest charm, in the study of synthetic chemistry is the certain evidence which it offers of the discovery and manufacture of many compounds now entirely unknown, whose effect upon human health, human life, and human happiness no one can possibly conjecture."

As regards the future supply of heat, which is no less important than that of food supply, Professor Berthelot speaks confidently of improved appliances enabling man to make use of the illimitable supply of the earth's central heat. In conclusion, the professor says: "If one chooses to base dreams, prophetic fancies, upon the facts of the present, one may dream of alterations in the present conditions of human life so great as to be beyond our contemporary conception. One can foresee the disappearance of the beasts from our fields, because horses will no longer be used for traction or cattle for food. The countless acres now given over to growing grain and producing vines will be agricultural antiquities, which will have passed out of the memory of men. The equal distribution of natural food materials will have done away with protectionism, with custom houses, with national frontiers kept wet with human blood. Men will have grown too wise for war, and war's necessity will have ceased to be. The air will be filled with aerial motors flying by forces borrowed from chemistry. Distances will diminish, and the distinction between fertile and non-fertile regions, from the causes named, will largely have passed away. It may even transpire that deserts now uninhabited may be made to blossom, and be sought after as great seats of population in preference to the alluvial plains and rich valleys."

THE present 1,500 foot tunnel and turbine wheel pit of the Niagara Falls Power Company will, when it shall work at its full capacity of 100,000 horse power, divert 3.64 per cent of the total volume of water and reduce the depth of the crest along the entire falls to the extent of 1½ inches.