IMAGE

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AN 1877 COLOR PHOTOGRAPH

THE COLOR REPRODUCTION in this issue of *Image* is a facsimile of one of the earliest known color photographs. It was taken by Louis Ducos du Hauron in 1877, of the city of Angoulême, France. The rare original, a three-color carbon print, is in the collection of the George Eastman House.

Ducos du Hauron was color photography's herald. In a remarkable little book, published in 1869, *Les Couleurs en Photographie,* he clearly described in theory several ways to make natural color photographs. He previsioned every technique before the integral tripack of Fischer's, which was brought to a practical state with the invention of the Kodachrome process by Mannes and Godowsky.

Instead of searching for a substance which, chameleon-like, would assume the color shining upon it, Ducos du Hauron imagined an indirect process. He envisaged taking three separate photographs, through green, orange and violet* glasses over the lens of the camera. He went on to show that from these black and white negatives prints or transparencies could be made.

But at the time he was writing he could not test his theory. The collodion plates he used were sensitive to the blue rays, and almost completely insensitive to the red and green rays. The rendition of colors in black and white was false. The sky in a landscape came out blank white in the photograph no matter how deep the blue or how dazzling the clouds. Red could not be distinguished from black. Trees were shown gray only because the greens contained a certain amount of blue.

A few years later, in 1873, Hermann Wilhelm Vogel of Berlin discovered that by adding a dye to the collodion coating of the plate, the sensitivity to colors other than blue was increased. A plate treated with the yellowish-red dye corallin, which absorbs yellow and green, showed a marked sensitivity to these colors.

This discovery enabled Ducos du Hauron to put his theory to practice. With his brother Alexandre he wrote a detailed instruction manual, *Traité Pratique de Photographie des Couleurs* (Paris, Gauthier-Villars, 1878). From it, we learn how the view of Angoulême was made.

The French experimenter used eosin for a sensitizer. He first chose aurin and chlorophyll, but found that both had drawbacks. Aurin—which increased the green and violet sensitivity—had to be used with distilled water. It did not keep. And it was incompatible with hygroscopic substances added to the plate to keep it moist. It must be remembered that with the collodion process, the photographer had to prepare each plate immediately before exposure, put it into the camera while still moist, and develop it at once. This technique, although inconvenient, was practical when making single exposures. But when it came to making three negatives in succession, it was impractical. Some way had to be found to keep the collodion moist so that by the time the first plate had been exposed the two others would still be moist and light sensitive. Sugar, syrup, tannin were used as these "preservatives." They could not be used, Ducos du Hauron said, with plates sensitized with aurin.

Chlorophyll—an orange sensitizer which is the green coloring matter of plants—he obtained from ivy. The difficulty lay in getting uniformity. The kind of ivy, where it grew, and the season when it was picked were all critical. Ducos du Hauron remarks that his assistant "became legendary as an ivy hunter in the parks of Paris."

The use of two sensitizers led to insuccess. Wet plates, made by hand without precision control, have slightly differing light response. It was preferable to use a single plate, and expose it in three sections.

He found that eosin, a new dye announced in 1876, sensitized to green, orange and blue. A very small amount of the dye was added to collodion and cadmium bromide. This was poured over the clean glass plate, which, while tacky, was plunged into a solution of silver nitrate, acidified with a few drops of nitric acid. The plate was then treated with a mixture of water, albumen and glycerine as preservative.

Three filters of colored glass, to fit over the lens for the successive exposures were required, and Ducos tells how to make them by flowing glass with colored varnish.

*"Vert, orangé, violette" in the text. The exact colors thus designated by the French experimenter can only be imagined.

The exposure which he suggested for a landscape, with a lens working at f/20, was 2 to 3 minutes with the orange filter in place, about a quarter of this time with the green filter, and about an eighth with the violet filter.

The recommended development was either with pyrogallic acid or iron sulfate, mixed according to normal formulas. The only unconventional part of the processing technique was flowing the plates before development with a solution of potassium bromide.

The resulting negatives analyzed the colors in the scene into three component parts. Although they contained no color, from them positives, reproducing the colors of the original scene, could be made by a variety of techniques. One way was to make a transparency of each negative, which was dyed in the color complementary to the filter through which the negative was taken. Thus the transparency made from the orange-filtered negative would be dyed blue, from the green-filtered negative, red, and from the violet-filtered negative, yellow. When the red, blue and yellow transparencies were superimposed, all the colors of the scene were visible. The drawback to this simple technique was its cumbersome form, and the fact that the glass sandwich had to be looked at against the light. It was not, like a black and white photograph, a *print* on paper, easily handled, examined and stored.

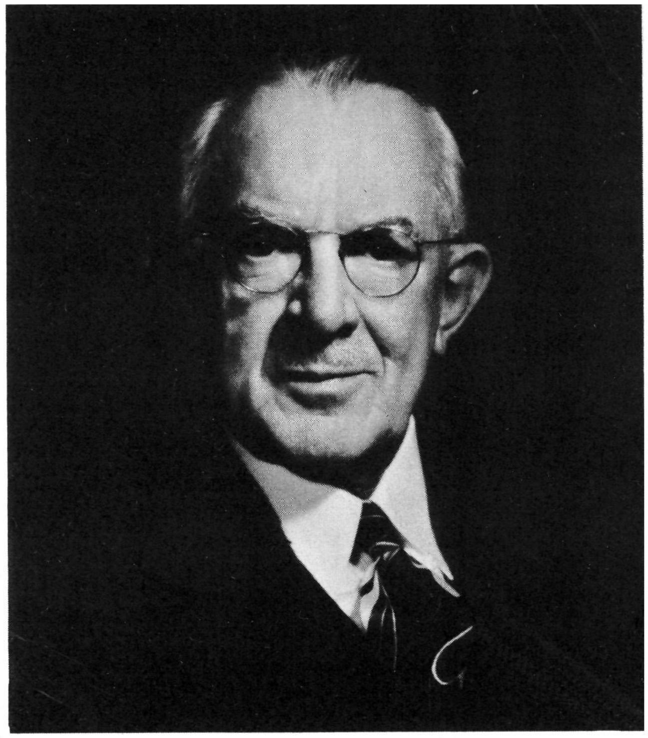
The second half of the instruction book by the Ducos du Hauron brothers tells how to make prints. The principle, of superimposing red, yellow, and blue images, remained the same. It was done by the carbon process.

The first step was to coat paper with gelatin and a pigment (carmine, Prussian blue, orpiment). These coated sheets were made light sensitive by treating them with an alcoholic solution of ammonia bichromate. It is the property of the bichromates to alter the solubility of gelatin in proportion to the light to which it has been exposed. Placed in contact with a negative, and exposed to light, the bichromated gelatin is hardened in varying degree. By simply washing the exposed sheet of paper in hot water, the unhardened gelatin is dissolved, leaving a positive image.

This Ducos du Hauron did, for each of the prepared sheets. He then transferred the yellow image onto a prepared temporary glass support by pressing the print against it. The gelatin adhered to the coating on the glass, so that the paper could be torn off. Next the yellow image was transferred to a final support of white paper. The process was repeated with the red and blue images, which were superimposed in exact register on the yellow. The result was a color print.

Ducos du Hauron's technique is still practiced with modifications. Fully panchromatic gelatin emulsions have replaced his eosin collodion. The taking filters are red, green, and blue; the positives are magenta, cyan, and yellow. For printing, either the carbro or dye transfer process is used instead of the more difficult carbon technique. But the principle is identical to the system worked out by the most remarkable figure in color photography's early history.

BEAUMONT NEWHALL



Loyd Ancile Jones, 1884-1954

L. A. JONES AND HIS WORK ON PHOTOGRAPHIC SENSITOMETRY

By C. E. Kenneth Mees

ON MAY 15, 1954, his friends were shocked to learn of the sudden death of Dr. L. A. Jones.

Loyd Ancil Jones graduated from the University of Nebraska in 1908 with a B.S. degree in electrical engineering, and in 1910 he took his A.M. degree in physics. He then went to the National Bureau of Standards as assistant physicist, doing research in photometry, colorimetry, spectrophotometry, spectroscopy, and retinal sensitivity. The head of the department of optics at the Bureau was Dr. P. G. Nutting. In 1912 Dr. Nutting accepted an invitation from Dr. C. E. Kenneth Mees to join the newly organized research laboratory of the Eastman Kodak Company and took Jones with him as his assistant. In 1916, when Nutting left the Kodak research laboratory, Jones was appointed chief physicist and held that position until he retired on May 1, 1954.

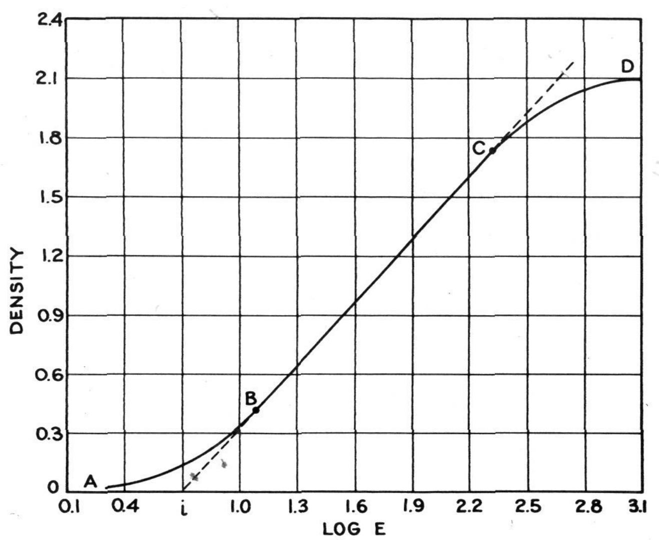
The subject which chiefly occupied his attention was that known as *sensitometry*. Sensitometry may be defined in general as the measurement of sensitvity and, in photography, as the science of measuring the sensitivity of photographic materials. In practice, however, photographic sensitometry includes not only the measurement of the sensitivity but the quantitative measurement of the relation between the image produced on a photographic material and the treatment to which it has been subjected, including exposure and development.

The foundations of modern sensitometry were laid by two amateur photographers, Ferdinand Hurter and Vero C.

PIONEER COLOR PHOTOGRAPH of the city of Angoulême, France, taken in 1877 by Louis Ducos du Hauron, researcher and theorist on color photography. The reproduction is made from a recently rediscovered original three-color carbon print, now in the George Eastman House.

Driffield. Their early work was directed toward methods of ascertaining the correct exposure in the camera. This involved a knowledge of the effective sensitiveness of the photographic material. At first the material used was wet collodion, but very soon ready-prepared gelatin dry plates took its place. The great variety of speeds in the new gelatino-bromide plates, so different from the almost uniform rapidity of the wet collodion plate, rendered the problem of correct exposure more difficult, and indicated strongly the importance of discovering some means of ascertaining their relative speeds and of numerically expressing them.

The first step to meet this need was a series of investigations to ascertain the law expressing the action of light on the sensitive plate. These investigations, published in



CHARACTERISTIC CURVE shows density versus exposure.

1890 in the paper "Photochemical Investigations and a New Method of Determination of the Sensitiveness of Photographic Plates," were the basis of sensitometry. Hurter and Driffield gave the plate a series of exposures and after development measured the deposit obtained to determine its relation to the exposure which had been given.

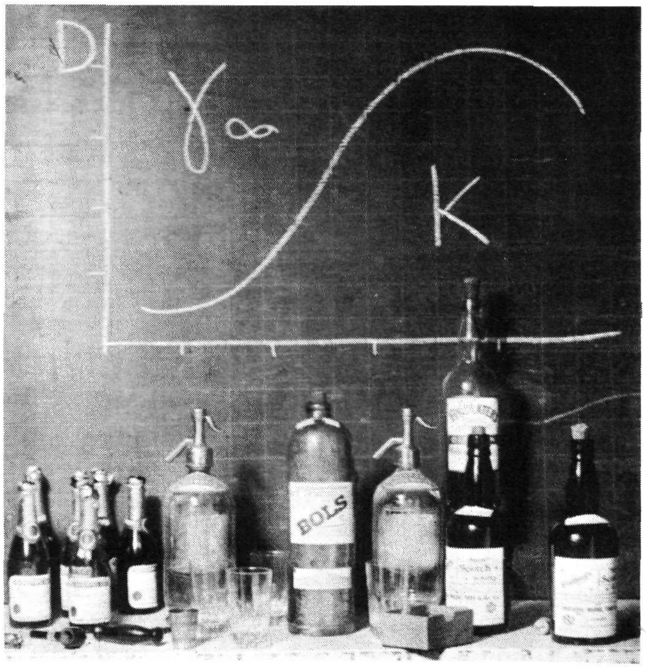
Since the mass of silver is difficult to measure chemically, they studied the relation between the light transmitted by the deposit and the silver per unit area. They found that they could calculate from the transparency of the deposit a quantity which they termed the "density," proportional to the mass of silver. They found that through a very considerable range of exposures the density increases arithmetically as the exposure increased geometrically; that is, the density is proportional to the logarithm of the exposure. They further found that the relation between the density and the logarithm of exposure, which they termed the "characteristic curve," is a straight line over only its central portion. The diagram shows the general shape of the curve, which falls into three portions, each merging imperceptibly into the next. There is, first, an induction period, and then the sensitive layer builds up density nearly linearly with exposure until the main portion of the curve is reached, where the density increases as the logarithm of exposure. Then, with high exposures, the density ceases to increase as rapidly as the logarithm of exposure until, finally, further exposure gives little or no increase in density. Still greater exposures, perhaps a million times more than that required to give the first perceptible density, cause reversal, and continued light action diminishes the density obtained upon development.

The characteristic curves of different films and plates give all necessary information about their photographic behavior provided that the curves are made for a series of times of development, so that the behavior of the material in the developer can be followed in relation to the deposit obtained for various exposures. The system of sensitometry which Hurter and Driffield originated was recognized as valuable, especially by manufacturers of photographic materials, but it came into use very slowly. The apparatus which Hurter and Driffield designed was necessarily rather primitive, and measuring a number of characteristic curves was a slow operation.

In 1901 S. E. Sheppard and C. E. K. Mees, while students at University College, London, took up the study of sensitometry, repeated Hurter and Driffield's work, and endeavored to improve the experimental methods used. They developed the acetylene burner as a standard light source, built convenient, enclosed exposing sensitometers, and used absorption photometers for measuring the density. Their work was published in 1907.

Soon after Jones entered the Kodak Research Laboratories, he started work on the sensitometry of photographic papers, and in 1914 he published an article on the subject in collaboration with P. G. Nutting and C. E. K. Mees. This was the first published report on the sensitometry of photographic papers. It involved the working out of methods for the measurement of reflection densities.

Once it was possible to obtain the characteristic curve for a printing paper, attention could be turned to a problem which had often been considered by Hurter and Driffield, the extent to which the brightnesses of the various areas of a photographic print resemble the brightnesses of the original subject; that is, how far the photographic process reproduces the tone values of the objects photographed. Hurter and Driffield published in the *Journal of the Chemical Industry* in 1891 a study on the relation between photographic negatives and their positives, but, presumably owing to the difficulties involved in measuring reflection densities, they confined themselves to transparent positives. Using the methods of paper sensitometry, Jones was able to work out a graphic method of the solution of tone reproduction problems in which he transferred a set of brightness values from the original subject through the densities of the negative to the reflection densities of the print and then directly compared the brightness values of the print with the brightness values of the original subject. These important observations were published in 1920.



SYMBOL OF PHOTOGRAPHIC SCIENCE is the characteristic curve. Photograph at left, titled "Mental and Other Pabulum of the Club" is from souvenir album presented to C. E. K. Mees by the Croydon Camera Club when he left for America in 1912. Medal, above, incorporates same symbol. Greek letter gamma is used by photographic scientists to express contrast.

Jones also adopted electric light sources in place of the acetylene burner and worked on filters for modifying the color of the light source to resemble daylight. He designed various methods of making a number of exposures of different amounts simultaneously upon the material tested and made improved sensitometers.

Besides their use by manufacturers, the improved sensitometric methods have been adopted very generally by the motion-picture industry, largely as a result of articles published by Jones and his associates.

With the development of color photography, sensitometry has become more complicated, since it is necessary to obtain characteristic curves for three primary colors and to interpret the result by analyzing the color deposits obtained. These requirements have been met by continually improved apparatus and methods, so that today there exist color densitometers which will make the necessary measurements on one area after another of an exposed strip of film through a series of color filters and then calculate, after each set of measurements, the analytical data and plot them automatically upon paper, a strip being completely measured and plotted in about ten minutes. Black-and-white sensitometry giving results comparable with, but far more accurate than, those obtained by Hurter and Driffield, can be carried out in less than a minute per curve.

Jones' work on tone reproduction led to a consideration of the effective speeds of photographic materials and of the terms in which these speeds should be expressed. He felt the need for an agreed standardization of emulsion speeds and worked actively on this subject as chairman of Committee Z-38 of the American Standards Association. As a result, he came to the conclusion that the effective speeds of photographic materials should be expressed in terms of the exposure required to give negatives which would produce prints of the best possible quality, and this required a psychophysical judgment of the quality of photographic prints which was applied on a considerable scale to the solution of a number of problems.

L. A. Jones made many other contributions to our knowledge of the photographic process and to the technology of photography, but his work on sensitometry will always be considered outstanding in photographic science.

NOTES

In the April issue of *Image* the date of the invention of the "Cylindrographe" panorama camera was given erroneously. P. Moessard first presented this camera, at the Versailles Photographic Society in July, 1884.

With this issue, *Image* suspends publication until September 1954.

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