IMAGE

Journal of Photography of the George Eastman House

Vol. III, No. 8 NOVEMBER, 1954

DR. C. E. KENNETH MEES, VICE PRESIDENT in charge of research of the Eastman Kodak Company, receiving the Franklin Medal from S. Wyman Rolph, president of the Franklin Institute on October 20, 1954 in Philadelphia.

FIFTY YEARS OF PHOTOGRAPHIC RESEARCH

C. E. KENNETH MEES

This is a copy of the talk given by Dr. Mees at the dinner given in his honor at the Franklin Institute in Philadelphia on the occasion of his being presented with the Franklin Medal, October 20th, 1954.

The citation which accompanies the presentation of the Franklin Medal this evening states that the medal is awarded for contributions to the scientific knowledge of the photographic process and for the development of a laboratory resulting in new photographic products. It seems to me that you might be interested in knowing how I came to devote myself to the study of the science of photography and to the direction of a laboratory of industrial research in the field of photography.

In 1900 I went to University College, London, as a student of chemistry under that great teacher and discoverer, Sir William Ramsay. I had come from a technical school, St. Dunstan's College, Catford, and another St. Dunstan's student and friend, S. E. Sheppard, had come with me. As Sheppard and I traveled together to University College, we discussed the work that was going on around us in the

THE FRANKLIN MEDAL, the highest scientific honor of the Franklin Institute Society was given in recognition of Dr. Mees' contributions to the advancement of the science of photography. Dr. Mees said "Laboratories and their scientific staffs are an integral part of our industrial organizations, and the success or failure of a business often depends upon the quality of its research."

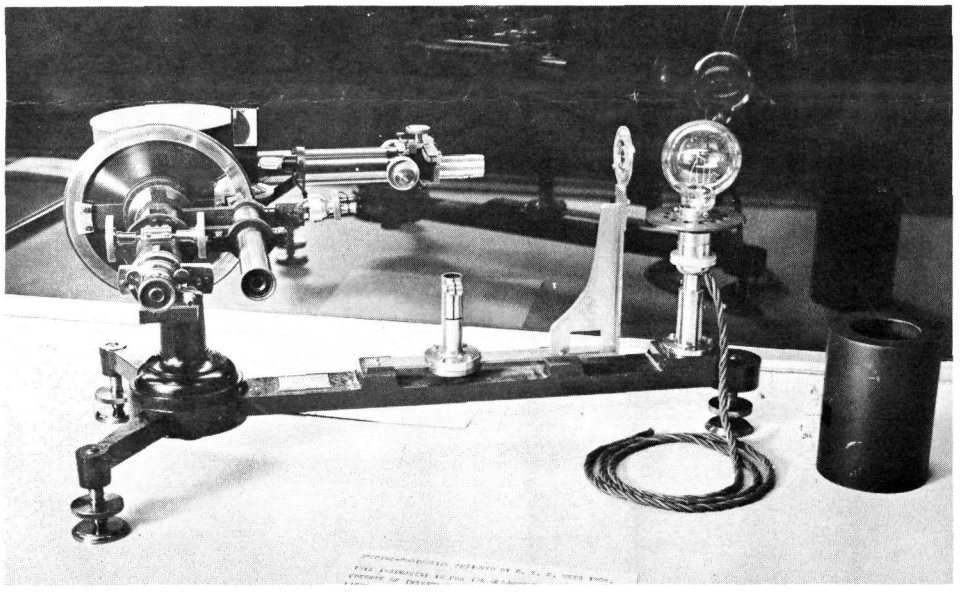
laboratory and the advances being made in physical chemistry. For some time I had been interested in photography. I had started to take photographs because I was unable to draw, and I wanted to illustrate in my notebooks the chemical apparatus that I was using. Whenever we discussed photography, we were impressed by the fact that we could find no satisfactory explanation of the photographic process in any of the chemical textbooks, nor when we turned to the photographic literature did we obtain much help. We wanted to know what happened to silver bromide when it was exposed to light, what it was that made it developable —particularly, being chemists, what happened during development, and what the factors were that controlled the rate of development. Before long Sheppard found a paper in the Journal of the Society of Chemical Industry published in 1890 by the physical chemist in charge of the laboratory of the United Alkali Company, Ferdinand Hurter, and an associate of his in the same company, V. C. Driffield. This paper, which we afterward found was well known in the photographic world, and which was entitled "Photochemical Investigations and a New Method of Determination of the Sensitiveness of Photographic Plates," came as a revelation. Here were people who had really studied photography scientifically. They had found a way of measuring the amount of image produced by exposure to light followed by development and of measuring the rate of development of the exposed image, so that in the work of Hurter and Driffield we had a model for an attack on the nature of the photographic process.

The apparatus that Hurter and Driffield had used was distinctly primitive, and with the advances that had taken place in physical chemistry since 1890 we believed that we could improve on their experimental methods and repeat their work with such improvements in the apparatus as we could achieve. Professor Ramsay was enthusiastic about such a program, and he arranged for Sheppard and me to start work on the subject and to present the work to the University of London in the form of theses as part of the requirements for the B. Sc. degree.

We erected our apparatus in the chemical laboratory at University College. As a standard, we adopted an acetylene burner light source supplied by a generator and one day had an explosion which has ever since given me a great respect for acetylene! Our primitive thermostats were made out of zinc pails, and to measure our densities we borrowed a Hüfner spectrophotometer from Professor Starling, the great professor of physiology at University College. We understood that he himself had borrowed it from Guy's Hospital, and beyond that we didn't inquire! With the more modern instruments, we laboriously repeated a good deal of Hurter and Driffield's published work and found that their equations for the growth of density during development could be applied to the increase of contrast. In 1903 Sheppard and I published two papers in the Photographic Journal on the development factor. We submitted our theses in notebooks to the University examiners and were both awarded the degree of B.Sc. by Research.

Both Sheppard and I by then were intensely interested in the work on the theory of the photographic process and we were convinced that by pursuing it further we should get results of value. We were anxious to continue it for another three years and then submit the results as theses for the London degree of doctor of science.

Photographic research requires a good deal of space since, in addition to the ordinary workrooms, darkrooms are needed, and there was no room in the crowded chemical laboratories of University College. Ramsay was willing to let us work at home and to supervise our work as if we



SPECTRO-PHOTOMETER DESIGNED BY DR. MEES and used by him and his colleague, S. E. Sheppard, during their college years in London to investigate the theory of the photographic process. The instrument was built by F. Twyman of the A. Hilger Co. of London in 1906. It was later used in the laboratories of Wratten & Wainwright until 1912 and then by Kodak Limited as a densitometer and as a spectro-photometer. It is now in the George Eastman House Collection.

were at the college and to let us submit our theses finally as internal students. I was living with my parents at Caterham at Surrey, and in a shed in the garden I built a darkroom, paneled the shed for warmth, and then fitted up the necessary apparatus, while Sheppard put similar equipment in a room in his father's house. For the next three years we worked at home, going to University College at intervals to attend lectures and to report to Ramsay. As a result, we were able to publish in various journals a series of papers covering our work on sensitometry, on the statics and kinetics of development, on the microscopic structure of the developed image, the chemistry of fixation, and the action of oxidizing agents on the latent image. We also submitted our theses to the University examiners and were awarded D.Sc. degrees in 1906. Altogether, Sheppard and I published 11 papers between 1904 and 1907, and they were collected and published in a book, "Investigations on the Theory of the Photographic Process," in 1907.

Then we were faced with the problem of what we should do next. Sheppard was awarded a post-graduate scholarship for two years and went to Marburg University to work as a post-doctorate student with Professor Karl Schaum, an outstanding authority in the field of photochemistry and editor of the *Zeitschrift für Wissenschaftliche Photographie.*

I discussed my future with Sir William Ramsay. Ramsay had a very clear vision of the part that science might play in industry, and though I argued with him for an academic career, he insisted that since I had worked on photographic science I must go into the photographic industry. Thus, by the time I was twenty-four years old, I had entered the two fields of work in which I have been engaged ever since—the study of the theory of the photographic process and the application of science to industry.

I started with Wratten and Wainwright Ltd., a small firm of photographic manufacturers in England who had made experimental plates for Sheppard and me, and there was successful in making new products which represented a considerable advance in photographic methods. New optical sensitizing dyes which had been made in Germany two or three years before enabled me to make commercial panchromatic plates which were much more sensitive to orange and red light than any others on the market. For use with them in the photography of colored objects, I made a series of light filters, and to this day the "Wratten" filters are standard in photographic work.

After I had been working at Wratten and Wainwright for about six years, I had a visit one day from Mr. George Eastman, whom I had met some two years previously in the United States. Later the same day, Mr. Eastman telephoned me, asking me to come to see him in London the next day, and explaining, much to my surprise, that he wanted me to go to Rochester to organize and direct a research laboratory for the Eastman Kodak Company. I told him I couldn't leave Mr. Wratten because he would not be able to carry on alone, and I could therefore only accept the offer if he would buy Wratten and Wainwright Ltd. Mr. Eastman at once agreed to buy our little business, and I went to Rochester in April, 1912, to build a laboratory.

I laid out the building plans with the engineers, went back to London, and in August migrated to Rochester with my family. Mr. Wratten joined Kodak Limited, and the manufacturing processes of Wratten and Wainwright were transferred to the Harrow factory of Kodak Limited.

My reason for accepting Mr. Eastman's offer was that I was still anxious to return to the study of the theory of photography. The pressure of practical problems at Wratten and Wainwright had made scientific work difficult, and Mr. Eastman offered the very opportunity that I had always wanted. I was interested in the idea of industrial research, and I was enthusiastic about the possibility of an integrated study of the theory of the photographic process.

The Rochester laboratory got into operation at the beginning of 1913 at Kodak Park with a staff of about twenty people. It was not under the control of the factory management, nor was it intended that it should concern itself primarily with manufacturing problems. It was decided that the laboratory should set as its main objective the study of the theory of the photographic process and its application to practical photography, so that the whole work of the laboratory was based from the beginning on photographic science.

An understanding of the nature of the photographic process requires knowledge of both the chemical and physical aspects of the subject, though these often overlap. Chemical aspects include the various processes of emulsion making; the distribution of size and sensitivity among the silver halide grains (which are the operating units in exposure and development); the reaction of the grains on exposure to light, that is, the nature of the change by which the grains become developable after exposure; the nature of the development reaction; and finally the structure of the silver produced in development. The physical aspects include the relation of the image in the camera to that formed in the developed negative and, after printing, in the positive; and the microstructure of the developed image, involving such factors as graininess, sharpness, and resolution. All these fields of work have been studied in the Kodak laboratories since 1912, and work on all branches of the photographic process is still being actively pursued.

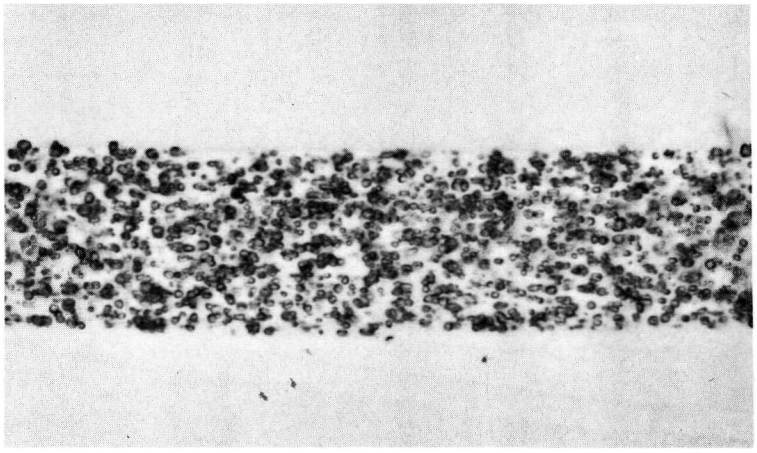
In 1942 sufficient progress had been made to enable us to incorporate in a book an account of photographic theory to date. When the book was revised this year, the twelve years that had elapsed made it necessary to rewrite the entire volume and to change about one-third of its contents! The dream that I had as a college student, that it was possible for the theory of photography to be studied by the application of the experimental methods of physical science, has been realized. At the same time, the application of this scientific work to industrial problems has enabled us to

Continued on page 54

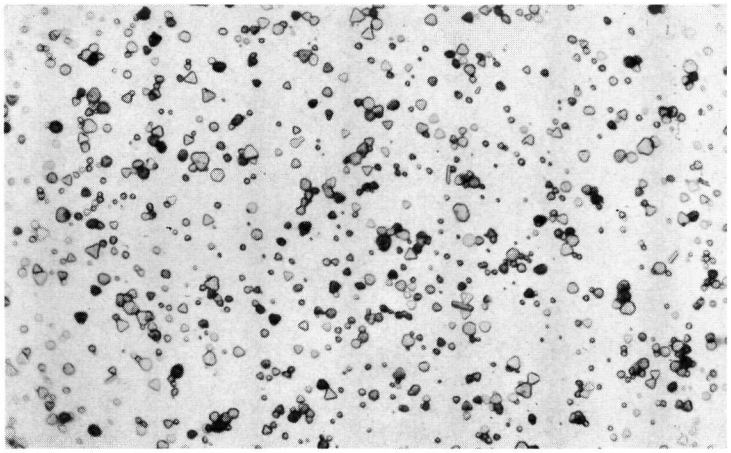
THE THEORY OF THE PHOTOGRAPHIC PROCESS

The theory of the photographic process involves a study of the nature of the light-sensitive layers used, of the factors which control their sensitivity to light, of the changes induced in them by the action of light, of the nature of development, and of the properties of the final image and its relation in tone values to the tone values of the scene from which it was produced.—C. E. K. MEES.

A STUDY OF THE NATURE OF LIGHT SENSITIVE LAYERS

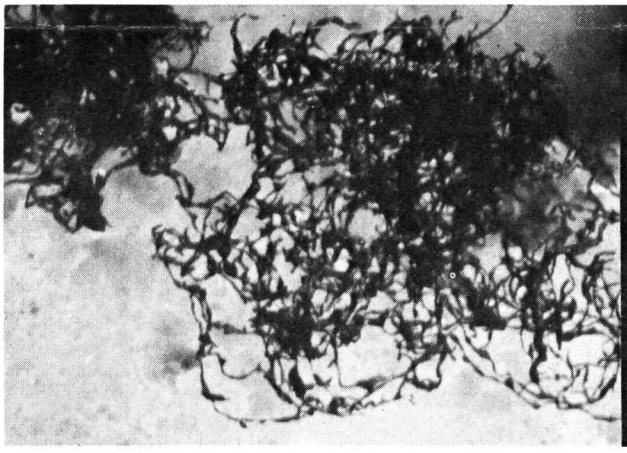


A highly magnified section of the emulsion layer of a modern film. If the film base were magnified to the same degree it would be three feet thick.

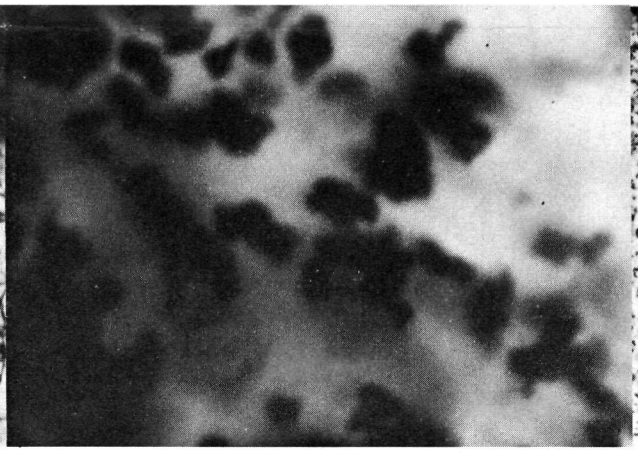


Emulsion enlarged 5000 times.

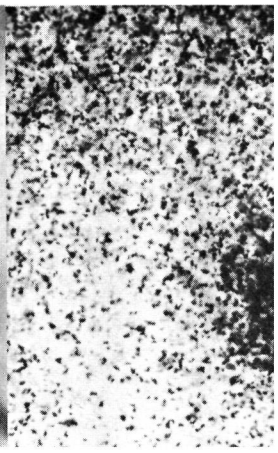
THE PROPERTIES OF THE FINAL IMAGE



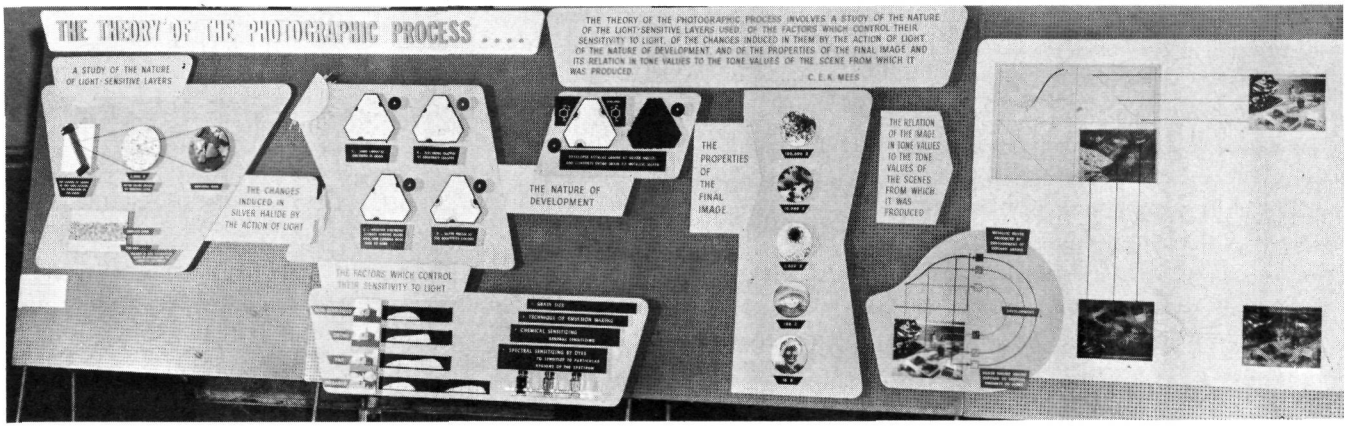
100,000 x magnification



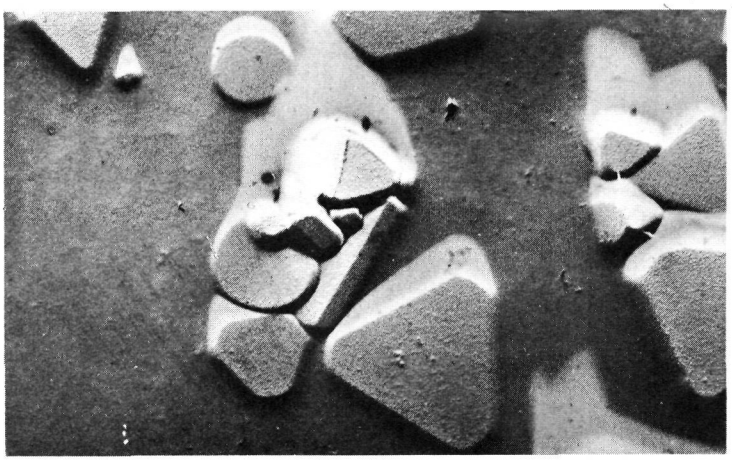
10,000 x



1,000 x



The Theory of the Photographic Process display panel that was on exhibition during the celebration at the Franklin Institute. Its main features are reproduced on this page.

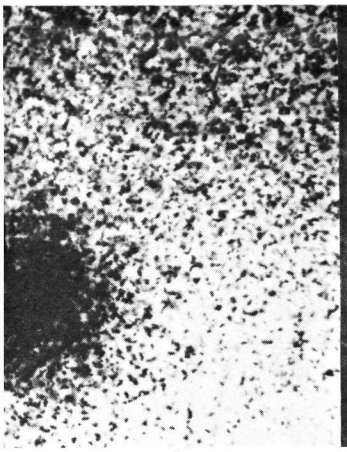


A photograph taken in an electron microscope at great magnification, showing individual grains of silver halide.

The changes induced in the silver halide grain by the action of light can be divided in four steps.

1. The light liberates electrons in the grain.
2. The electrons are trapped at the tiny sensitivity centers of the grain.
3. The negative electrons attract positive silver ions.
4. The two combine to form silver nuclei at the sensitivity centers at the edge of the grain.

The action of the developer is to reduce progressively the entire silver halide grain to metallic silver. The silver nuclei, which are the result of the action of light, serve as starting points for this reaction.



100 x

10 x

MEES: *continued from page 51*
make a great deal of progress in the manufacture of photographic materials and in the development of new applications of photography.

Industrial research has succeeded not only in the Kodak Company but everywhere else. Today our industries are founded on scientific research. Laboratories and their scientific staffs are an integral part of our industrial organizations, and the success or failure of a business often depends upon the quality of its research. I must add that if the goals to which Sir William Ramsay pointed fifty years ago have been reached, the credit belongs to the large group of scientists and technologists who have done the work. I cannot name them individually, but it is their work that you are acknowledging in awarding the Franklin Medal for contributions to the scientific knowledge of the photographic process and for developments in the art of photography.

October 4, 1954

BOOK REVIEWS

THE THEORY OF THE PHOTOGRAPHIC PROCESS, by Dr. C. E. Kenneth Mees. Revised edition. New York, Macmillan, 1954. 1133 pages. Illustrated. $21.50.

The following review is excerpted from *The British Journal of Photography,* September 3, 1954.

The first edition of this encyclopaedic work appeared in 1942. As the Preface to the revised edition points out, so much progress has been made in the development of photographic theory that the new edition is largely rewritten. The Table of Contents gives the names of the editors of the five sections into which the text is now divided and also the names of the authors of the 25 chapters comprising the main text of the book. The content and order of the chapters are changed and three new chapters have been introduced, namely, The Action of Charged Particles on the Photographic Emulsion, the Latent Images Produced by X-Rays, and the Sensitometry of Colour Films and Papers. One chapter of the first edition has been omitted, that on the Photographic Aspects of Sound Recording.

Great care has been taken to clarify any statement in the first edition which could be suitably simplified on the one hand or amplified on the other. The order in which the various subjects are presented is logical and sound, and makes for continuity in the picture of the photographic process as a whole.

It is very probable that the practicing photographer will find more interest in the fifth part, for here the general problems of sensitometry are discussed, together with such other practical matters as The Theory of Tone Reproduction, and The Structure of the Developed Image. This part might well be thought of as a memorial to Lloyd A. Jones, for his work and that of his collaborators provide the major part of the chapters.

The last chapter is one of the new additions, The Sensitometry of Colour Films and Papers. At the outset it can be admitted that few more difficult subjects are found in the whole field of photography than the problem of the reasonably correct rendering of colour; and that if black-and-white sensitometry can pose difficult problems, the sensitometry of colour materials will be vastly more difficult. This chapter of some forty pages is a remarkable achievement. Commencing with the elementary principles of colour photoraphy an explanation is given of how a satisfactory representation of an object in colour is obtained, the nature and the reason for the compromise are explained. It is also made clear that the discussion in the chapter relates to subtractive as well as additive processes.

Photographic theory to-day is an immense field, the way to its understanding is no simple highway. It calls for understanding in most of the sciences and, in addition to its comprehensiveness, possesses its own peculiar difficulties. If any true guide can be condensed into one volume, Dr. Kenneth Mees and his collaborators have succeeded in such an endeavour. *The Theory of the Photographic Process* is both invaluable and indispensable for every photochemical laboratory and to every serious researcher in any of the many fields covered by its comprehensive title. It is a most impressive piece of work for which the sincere thanks of the whole scientific community can be offered, for this book is essential to every scientific user of photography and no other work covers the ground.

PROGRESS IN PHOTOGRAPHY, by D. A. Spencer, Editor-in-Chief. London and New York, Focal Press, Vol. I, 1940-1950. 460 pages, illustrated, £ 2.2.0. Vol. II, 1951-1954. 334 pages, illustrated, £ 2.10.0.

These are the first two volumes of what is expected to be a continuing publication and a standard reference work. The aim and scope of the books may be best described by quoting from the dust jacket.

"*Progress in Photography* is a pioneering effort at presenting a comprehensive reference work on developments in fundamental aspects of photography and cinematography.

"It records the significant advances achieved by scientific research and technological development all over the world towards making photography a more versatile and efficient tool.

"In the past similar highlevel sources of information on photography have been accessible only to readers in languages other than English; yet, even these foreign surveys ceased to be published a considerable time ago.

"Meanwhile, much of the fundamental research, and the industrial development flowing from it, has shifted from its former European centers towards the West.

THE PROGRESS MEDAL was first given to Dr. Mees in 1913, then again in 1953 with the same citation. Medals awarded Dr. Mees now number sixteen.

"At the same time the steadily growing tendency towards specialisation has left individual scientists and technicians facing increased difficulties. In trying to keep step with other workers, they are more than ever in need of summarised information about complementary fields of work and wider trends of thought.

"The Second World War and its aftermath dramatically disrupted most of the established lines of communication that used to serve for exchanging ideas, securing material and comparing results.

"That is why the task assigned to the present volume has been first and foremost of bridging the gap of approximately ten years during which records of progress in different countries are extremely difficult to come by in any convenient form.

"Facing this task almost immediately after the war and still having only restricted facilities at their disposal, the Editors of this work in Britain, France, Switzerland and the United States decided to confine themselves largely to assembling as much material as could be offered to them by sixty-eight authoritative contributors, submitting eighty-one reports. It is left to subsequent volumes to complement and balance this survey, to add to it later information as it may become accessible, or critically to interpret and evaluate any point that may prove contentious."

Information on dust covers is apt to be a trifle overenthusiastic; these two books, however, live up to the program.

The advance in all fields of photography, except picture making, are presented with authority; sources and bibliographies are included in generous quantities. The surveys are remarkable for their compactness and the books themselves for their inclusiveness. They are in themselves an indication of progress in photography and fill a long regretable gap in the international exchange of ideas on technical and scientific matters in photography.

PUBLICATIONS BY C. E. KENNETH MEES, D. SC.

The total list of publications numbers over 228 separate titles. For this bibliography the important scientific papers and those concerned with the general problems of research have been selected.

Schrötter's Carbonic Acid Apparatus. *Chem. News,* **85**:251, May 1902.

On the Development Factor. *Phot. Jour.,* **27**:48, 1903. (With S. E. Sheppard.)

On the Highest Development Factor Attainable in Any Plate. *Phot. Jour.,* **27**:199, 1903. (With S. E. Sheppard.). Introduces gamma infinity for the first time.

Instruments for Sensitometric Investigation, with an Historical Resume. *Phot. Jour.,* **28**:200, 1904. Biobiligraphy, (With S. E. Sheppard.)

The Sensitometry of Photographic Plates. *Phot. Jour.,* **28**:282, 1904. Bibliography. (With S. E. Sheppard.)

Die Chemischen Reaktionen im Hydrochinonentwickler. *Zeit. Wiss. Phot.,* **2**:5, 1904. (With S. E. Sheppard.)

The Theory of Photographic Processes — On the Chemical Dynamics of Development, I. *Proc. Roy. Soc.,* 74:447, 1904. (With S. E. Sheppard.)

On Some Points in Modern Chemical Theory and their Bearing on Development. *Phot. Jour.,* **29**:241, 1905. (With S. E. Sheppard.)

The Theory of the Photographic Processes—II. On the Chemical Dynamics of Development, including the Microscopy of the Image. *Proc. Roy. Soc.,* 76A:217, 1905. *Phot. Jour.,* **29**:281 and 318, 1905. (With S. E. Sheppard.)

The Molecular Condition in Solution of Ferrous Oxalate. *Jour. Chem. Soc.,* **87**-I:189, 1905. (With S. E. Sheppard.)

Theory of Fixation and the Action of Thiosulphate on Development. *Phot. Jour.,* **30**:235, 1906. Bibliography. (With S. E. Sheppard.)

Orthochromatic Plates and Filters. *Brit. Jour. Phot.,* 53:430, 1906. (With W. J. Smith.)

The Action of Substances upon the Latent Image. *Phot. Jour.,* **31**:65, 1907. (With S. E. Sheppard.)

A Measurement of the Efficiency of Dark Room Filters. *Phot. Jour.,* **31**:267, 1907. (With J. K. Baker.)

Rapid Filter Blue. *Brit. Jour. Phot.,* Col. Suppl. 54:62, 1907. (With S. H. Wratten.)

The Wedge Spectrograph. *Brit. Jour. Phot.,* 54:384, 1907. (With S. H. Wratten.)

Variations in the Watkins Factor. *Brit. Jour. Phot.,* 54:560, 1907. (With S. H. Wratten.)

Screen Plate Colour Photography. *Jour. Roy. Soc. Arts,* Jan. 17:195, 1908. (Society of Arts Medal Award.)

The Photography of Coloured Objects in Principle and Practice. *Brit. Jour. Phot.,* **55**:735, 754, 770, 778, 1908.

Plates Sensitized with Dicyanine and Photography of the Infra Red. *Phot. Jour.*, 32:25, 1908. (With S. H. Wratten.)

The Construction of One-Exposure Cameras for Three-Colour Photography. *Brit. Jour. Phot.*, Col. Suppl. 55:58, 1908.

On the Resolving Powers of Photographic Plates. *Proc. Roy. Soc.*, 83A:10, 1909.

A Report on the Present Condition of Sensitometry. *Brit. Jour. Phot.*, 56:685, 1909.

On Some Experimental Methods Employed in the Examination of Screen Plates. *Phot. Jour.*, 34:197, May 1910. (With J. H. Pledge.)

New Investigations on Standard Light Sources. *Phot. Jour.*, 34:287, 1910. *Brit. Jour. Phot.*, 57:627, 1910. (With S. E. Sheppard.)

On the Fogging Power of Developers—General Introduction and the Hydroquinone Developer, I. *Phot. Jour.*, 35:226, 1911. *Brit. Jour. Phot.*, 58:491, 515. (With C. Welborne Piper.)

On the Ratio between Diameter of the Photographic Image of a Point and the Exposure which Produced It. *Astrophys. Jour.*, 33:81, 1911.

On the Fogging Power of Developers—Sulphite Fog and Solubility of Silver Bromide in Sulphite Solutions, II. *Phot. Jour.*, 36:221, 1912. (With C. Welborne Piper.)

The Photographic Industry. *Jour. Soc. Chem. Ind.*, 31:307, 1912. *Brit. Jour. Phot.* 59:326, 1912.

A New Laboratory for Research in Optics and Photography. *Sci. American*, Supplement, p. 56, 1913. *Phot. Rundschau.*, 51:300, 1914.

The Physical Chemistry of Photographic Development. *Jour. Am. Chem. Soc.*, 35:1727, 1913. *Brit. Jour. Phot.*, 60:935, 1913.

The Future of Scientific Research. *Brit. Jour. Phot.*, 61:692, 1914.

Light Filters for Use in Photometry. *Trans. Ill. Eng. Soc.*, 9:990, 1914.

The Sensitometry of Photographic Papers. *Phot. Jour.*, 54:342, 1914. *Brit. Jour. Phot.*, 62:9, 1915. (With L. A. Jones and P. G. Nutting.)

Artificial Illuminants for Use in Practical Photography. *Trans. Ill. Eng. Soc.*, 10:947, 1915. *Jour. Frank. Inst.*, 179:481, 1915. *Photo Era*, p. 76, 1916.

Physics of the Photographic Process. *Jour. Frank. Inst.*, 179:141, 1915. *Brit. Jour. Phot.*, 62:165, 1915. *Bull. Soc. Franc. Phot.*, 6:309, 1919.

The Organization of Industrial Scientific Research. *Science*, 43:763, 1916. *Nature*, 97:411, 431, 1916.

The Optical Properties of Light Filters. *Jour. Opt. Soc. Amer.*, 1:22, 1917. *Brit. Jour. Phot.*, 64:462, 1917.

The Photographic Rendering of Tone Values. *Studio Light*, May-August, 1917.

A Simplified Method of Writing Developing Formulae. *Brit. Jour. Phot.*, 64:535, 1917.

A Photographic Research Laboratory. *Sci. Monthly*, 5:481, 1917.

Planning a Research Laboratory for an Industry. *Jour. Ind. Eng. Chem.*, 10:476, 1918. *Sci. Monthly*, p. 54, July, 1918.

A New Yellow Dye and Light Filters Made from It. *Brit. Jour. Phot.*, 66:48, 1919. Jour. *Ind. Eng. Chem.*, 11:454, 1919.

Report on the Production of Synthetic Organic Chemicals in the Research Laboratory of the Eastman Kodak Company for the Years 1918-1919. *Jour. Ind. Eng. Chem.*, 11:1141, 1919.

The Production and Supply of Synthetic Organic Chemicals in the United States. *Jour. Soc. Chem. Ind.*, 39:230, 1920. (With H. T. Clarke.)

The Structure of the Photographic Image. *Jour. Frank. Inst.*, 191:631, 1921. *Bull. Soc. Franc. Phot.*, 8:184, 1921. (John Scott medal award.)

The Measurement of Color. *Jour. Ind. Eng. Chem.*, 13:729, August, 1921.

Some New Sensitizers for the Deep Red. *Brit. Jour. Phot.*, 69:384, 1922. *Jour. Ind. Eng. Chem.*, 14:1060, 1922. *Bull. Soc. Franc. Phot.*, 9:234, 1922.

Recent Advances in Photographic Theory. *Jour. Frank. Inst.*, 195:1, 1923. *Brit. Jour. Phot.*, 70:139, 1923. *Nature*, 111:399, 1923.

Motion Picture Photography for the Amateur. *Jour. Frank. Inst.*, 196:227, 1923.

Photographic Reproduction of Tone. *Phot. Jour.*, 64:311, 1924. *Brit. Jour. Phot.*, 71:445, 1924. *Phot. Ind.*, 24:131, 1926.

Research as the Enemy of Stability. *Indus. and Eng. Chem.*, 19:217, 1927.

Photography—(all sections, including motion pictures, revision of 1925 writing.) *Encyclopaedia Britannica.*

The Processes of Color Photography I-IV. *Jour. Chem. Ed.*, 1928-1929.

The Physics of Photography. *Brit. Jour. Phot.*, 76:135, 1929. *Phot. Rev.*, 41:279, 1929.

Amateur Cinematography and the Kodacolor Process. *Jour. Frank. Inst.*, 207:1, 1929. *Brit. Jour. Phot.*, 76:46, 1929. *Phot. Korr.*, 65:21, 1929.

The Publication of Papers from Research Institutions. *Science*, 70:502, November, 1929.

Photographic Plates for Use in Spectroscopy and Astronomy, I. *Jour. Opt. Soc. Am.*, 21:753, 1931. *Brit. Jour. Phot.*, 79:410, 1932.

The Scope of Research Management. *Indus. and Eng. Chem.*, 24:65, 1932.

Photographic Plates for Use in Spectroscopy and Astronomy. *Jour. Opt. Soc. Am.*, 22:204, 1932.

Photographic Plates for Use in Spectroscopy, III. *Brit. Jour. Phot.*, 80:560, 1933. *Phot. Ind.*, 31:834, 1933. *Jour. Opt. Soc.*, 23:229, 1933.

Recent Advances in Sensitizers for the Photography of Infrared. *Jour. Opt. Soc. Am.*, 23:216, 1933. *Phot. Jour.*, 73:258, 1933. *Phot. Ind.*, 31:1064, 1933. (With F. M. Hamer, and L. G. S. Brooker.)

Scientific Thought and Social Reconstruction. *Elec. Eng.*, 53:381, 1934. *Sigma Xi Quarterly*, 22:13-24, 1934.

Some Photographic Aspects of Sound Recording. *Jour. Roy. Soc. Arts*, 82:924, 1934. *Bull. Soc. Franc. Phot.*, 22:11, 1935. *Jour. S.M.E.P.*, 24:285, 1935.

Photographic Plates for Use in Spectroscopy and Astronomy, IV. *Jour. Opt. Soc. Am.*, 25:80, 1935.

Photography and the Advance of Pure Science. *Jour. Frank. Inst.*, 226:281, 1938.

The Modern Era of Photography. *Phot. Jour.*, 79:225, 1939.

Direct Processes for Making Photographic Prints in Color. *Jour. Frank. Inst.*, 233:41, 1942. Also published *Phot. Jour., Jour. SMPE Jour. PSA, Cine Technician, Amer. Phot., Can. Jour. Med. Tech., La Tech. Cinemat., Minicam Phot., Camera Craft, Brit. Kinemat. Soc. Jour.*, and *U. S. Camera*, between 1942 and 1945.

The Kodak Research Laboratories. *Phot. Jour.*, 88A:50-57, March 1948. *Proc. Roy. Soc.*, 192A:465-479, March 1948.

The Growth of Industrial Research. *Bull. Amer. Ceramic Soc.*, 29:448-453, Dec. 1950.

The View Ahead in Chemistry. *Chem. Eng. News*, 29:4062-4064, Oct. 1951. *Chemistry*, 25:27-43, Oct. 1951. (A.C.S. Diamond Jubilee Lecture.)

Recent Progress in Astronomical Photography. *Smithsonian Inst. . .* Publ. 4151, p. 205-218. 1953.

History of Professional Black-and-White Motion-Picture Film. *Jour. S.M.P.T.E.*, 63:134-137, Oct. 1954.

POSITION OPEN

A position is open at George Eastman House for a man or woman to serve as guide, custodian of the collection, and general assistant. Knowledge of photography essential, must also have experience in research and writing. For further details write Gen. O. N. Solbert, Director of the George Eastman House.

ERRATUM

An English correspondent correctly identifies the castle in the photograph, by R. Murray, on page 44 of the October issue as Carnarvon (or Caernarvon) Castle built by King Edward I, in Wales.

IMAGE, Journal of Photography of the George Eastman House, 900 East Ave., Rochester 7, New York. Editors: Oscar N. Solbert, Beaumont Newhall, James G. Card, Minor White. Editorial Assistants: Charles Arnold, George Pratt, Warren C. Stevens, Erwin J. Ward. Printed in U.S.A.