10. Summary

The projective methods of Resection in Space reach safely the highest possible accuracy level, that of the physical limit of camera accuracy, and they combine this quality with a high computational speed. These results encourage broad applications in flight mechanics as well as in photogrammetric triangulation.

WORK OF THE KODAK RESEARCH LABORATORIES*

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As the available time will not permit including the Research Laboratories in the inspection trip through Kodak Park, I will describe some of the work of the Laboratories, the general organization, and a part of our working methods. I will also describe how our interest in photogrammetry is related to our operations.

In addition to those in Rochester, New York, there are several research laboratories in the Eastman Kodak Company and its subsidiaries. The laboratories at Rochester are concerned almost entirely with work on photographic processes and products, as are the laboratories of Kodak limited at Harrow, England, Kodak Pathé at Vincennes and Sevran, France, and a small research group in the Research Laboratory at Melbourne, Australia, as part of Kodak Australasia. In addition, there is a research laboratory at the Eastman Kodak Company's division, Tennessee Eastman Company, at Kingsport, Tennessee, in which work is done on organic chemistry as related to materials for production of film support, fibers and plastic molding powders. The development and pilot plant work at the Kingsport laboratory on gas reactions for the synthesis of organic compounds resulted in the decision to erect a plant at Longview, Texas, as the Texas Eastman Company division of Eastman Kodak Company. The laboratory at Kingsport is now doing work in this field as part of the Texas Eastman development.

The description in this paper will be restricted to the work at the Rochester Research Laboratories. The organization consists of three large divisions directly concerned with photography; these are the Divisions of Black-and-White Photography, Color Photography, and Emulsion Research. In addition, there

are Divisions of Physics and Chemistry and, of course, an Administrative Division, to take care of financial, personnel, maintenance and similar matters concerned with operation.

The Rochester Research Laboratories also have under their administration the division in which the Eastman Organic Chemicals are synthesized, although these are distributed through the Distillation Products Industries. Under the same supervision is the rather large production operation for the manufacture of couplers and other compounds used in color photography, as addenda to photographic emulsions and some of the materials used in processing solutions.

The main building of the Research Laboratories contains the photographic divisions, physics division, and a part of the chemistry division. The Physical Chemistry and Analytical Departments are in the main building, but much of the synthetic organic research is done in a building about two miles away in what is known as "Kodak Park West." Buildings housing the Synthetic Chemistry Department—devoted to the manufacture of fine organic chemicals—and the synthesis of materials for color photography are also located at Kodak Park West. We are proud of the synthetic chemicals made in the department of the Synthetic Chemistry. Now offered are over 3,500 chemicals for use by universities and in industrial research. In addition, also made available are the stable isotopes Nitrogen 15 and Carbon 13, as well as a few of their compounds, for use in research. High columns for preparing these by diffusion processes are located in the main Research Laboratories building.

It is the general policy to do a minimum of late development and pilot plant work in the Laboratories. Therefore, development sections are attached to each of the operating departments. In making the transition in the introduction of new products or new manufacturing processes which have originated in the Laboratories, there is, of course, very close cooperation with the manufacturing groups.

The work may also be divided between our activities in the field of fundamental investigation and the effort devoted toward new processes and products.

Since the Research Laboratories were organized in 1912, it has always been the policy to devote a very considerable proportion of the time and effort to the study of the science of photography. During the past 40 years we have published approximately 1,600 papers in the scientific journals relating to our work in this field. Our theoretical work dropped to a low ebb during World War I, and decreased practically to the vanishing point during World War II. In these trying periods it appeared to us that all of our work should be directed toward the military applications of photography, and this was done. In the interval between the two World Wars, and in recent years, we have maintained our work in fundamental research at about 25 per cent of the total effort of the Laboratories. The results have contributed to the advancement of knowledge of the science of photography. The gains in such problems as the mechanism of optical sensitizing, the theoretical work on the graininess and granularity of photographic images, the mechanism of photographic development, and the theory of color photography have been fruitful in enabling our people engaged in development work to proceed with a somewhat better background than would otherwise have been the case.

I will now briefly describe the general types of problems with which each division is concerned.

In the Division of Black-and-White Photography, much work has been done in studying photographic developing agents and the compounding of new developers. The current formulas for Durol developer, Microdol developer, Rapid X-ray developer, and other well-known developers, originated in this
division. Much work was also done on the single powder developers which were recently introduced. Improved fixing baths, hypo eliminators and washing methods have been investigated, and fruitful results obtained. In this division, work on the rapid processing of motion picture film, spray processing, techniques and apparatus for use in amateur photofinishing establishments, has yielded interesting and important results.

There is a Photographic Service Department in the Black-and-White Photography Division. Document reproduction is done as a service to the Laboratories in reproducing the many papers and articles and other documents for which photographic copies are required. In addition, considerable investigative work is done on new methods for improving the quality of photographic reproduction, or increasing the simplicity with which such reproductions can be made.

Work on materials for graphic arts, carried on in this division for many years, has been intensified since the war. What has been done on contact screens as a substitute for the earlier types of halftone screens has led to products which have been well received. New masking techniques which have been evolved in the Graphic Arts Department of the Black-and-White Photography Division have enabled results of definitely improved quality to be obtained by the printing industry. The theory of halftone reproduction has been the subject of investigation for many years. The results in this field have been published in technological journals for study by those interested. We have now in the late development stage a new lithographic process for "short-run" color reproduction, about which we are very enthusiastic and which appears to offer promise of wide utility.

Photographic materials are widely used in microscopy, and investigations of the photographic materials through using the microscope have been of interest. A group has been working in these fields since the early days of the Laboratories. Many papers have been published on the use of photographic materials and techniques in the field of microscopy. In connection with the investigative work in photomicrography, size-frequency determinations of photographic emulsions have been studied, and the methods for size-frequency distribution of silver halide grains in emulsions have been markedly improved in recent years.

Photography in the tropics presents difficulties and problems not encountered in more moderate climates. While conditions can be simulated in the temperate zones, many problems can be investigated more satisfactorily under the operating conditions of a tropical country. For this purpose there was founded several years ago a tropical laboratory at Panama City which is under the administration of the Division of Black-and-White Photography of the Laboratories. Two aspects of the work at Panama are testing photographic apparatus and materials under tropical conditions, and handling and processing of photographic emulsions under high temperatures and at high humidities. The subject of photographic exposure under the tropical sun is also somewhat different from that in more northern or southern climates; it is also being studied. Work in the tropical laboratory has resulted in improvements in apparatus to better withstand the attack of fungi and insects. Much of our apparatus recently introduced on the market has been "tropicalized" with a fair measure of success. In handling photographic materials in the tropics, developer modifications to decrease emulsion swelling, the use of hardeners to enable higher temperature processing solutions to be employed, and the benefits of hypo eliminators have been investigated with interesting results. It is felt that work at the tropical laboratory is showing definite progress in this difficult field.

In the Color Photography Division a succession of new products have been originated and many of these are familiar to you. The battle of Kodachrome Film was fought there in the early '30's, and many improvements in Koda-
chrome Film through the intervening period have come from work in this division. The introduction of Kodacolor Roll Film and Prints in 1942 stemmed from work on Ektachrome Aero Film for the military services, and, of course, the recent introduction of Eastman Color Negative and Eastman Color Print films for the professional motion picture industry represent the operational phase resulting from the early work in the Division of Color Photography on these materials.

Many problems in the synthesis of couplers and their use have been the subject of much work in the Color Photography Division. Work on processing has required a very considerable effort to evolve a system which had good stability and which would yield highly reproducible results. Many of the control methods were worked out in this division. These, of course, are of great importance if a large-scale color processing is to be successful.

For a time the Color Photography Division operated the processing of Kodachrome Sheet Film which was recently discontinued. On occasions, development work leads to pilot plant operation which cannot be done elsewhere and, in these cases, the work is undertaken by the Laboratories. This, however, can have its repercussions; as an example, I mention the production of Kodachrome prints. There was no place in Kodak Park to which this could be transferred, and the Laboratories were in the business of making Kodachrome prints which amounted to somewhat over a million dollars per year. This work was subsequently transferred to Chicago where Kodachrome prints are now being made.

Various color processes have been investigated in the Color Photography Division, and are now the subject of a considerable amount of work. Efforts are continually being made to improve color reproduction and to evolve new materials with better properties than those now available. An example is the current work on the internegative used in making color prints from Kodachrome slides.

As a result of the complexity of color photography it appears to us that a large amount of work is required to make small gains. An improvement in one property may well result in a definite loss in two other important characteristics, and progress to those of us engaged in the field seems slow. On the other hand, when viewed over the years, I believe that the number of new products reflects a reasonably satisfactory over-all result. Much work remains to be done; we are continuing this job with enthusiasm and vigor.

The Emulsion Research Division is responsible for studying various methods for making photographic emulsions, and the effect of addenda of various types with reference to their characteristics. This includes work on the synthesis of sensitizing dyes. In this field I believe we have made distinct gains in our fundamental studies in recent years, so that we now have a reasonably clear picture of the mechanism of optical sensitizing. Such phenomena as dye sensitizing and supersensitization have now been reasonably well explained. In the field of chemical sensitizing, fundamental investigations have also yielded interesting and useful results. There has, of course, been much work on preparing special emulsions for use in the various color materials, as well as in the black-and-white field. Experimental programs on emulsions with highly specific characteristics, such as those used in making Autopositive paper and special products for the motion picture industry, and the graphic arts field, have established new fields for photography, but new materials for amateur, portrait and commercial use have not been overlooked.

In the Emulsion Research Division we are also running a small, though we feel important, production operation. I refer to the more than 150 varieties of special plates and films made for scientific use. This includes special materials
for astronomy, spectroscopy, and the various types of emulsions for use by nuclear physicists.

In the Chemistry Division, separately from the production operation of the Synthetic Chemistry Department, a considerable amount of work is being done on physical chemistry as related to various aspects of photography, such as investigating the mechanism of the gelation and hardening of gelatin and studies of the physical properties of film support. This includes work on x-ray diffraction, electron diffraction, infrared and ultraviolet spectroscopy. The analytical work of the Laboratories is carried on in a separate department of this division in which (as in the case of document reproduction) the main function is service to the various departments requiring analytical determinations. Beside this, however, the Analytical Department has been very active in evolving new methods of analysis required by special problems which have confronted various departments in the Laboratories and in the operating divisions. In the latter case, the procedures, after being well established, are turned over to the appropriate laboratories in the manufacturing departments.

The Organic and Polymer Departments of the Chemistry Division are working on a wide variety of synthetic materials for various purposes. Both simple organic compounds and polymers come under the purview of this group. In the case of organic compounds, work on dyes for color filters has included such items as working out the structure of widely used but heretofore unanalyzed materials, such as Toluidine Blue. The work on ultraviolet absorbers for various applications, backings for photographic materials, and tinting dyes for x-ray support are among the problems tackled. Much effort has also been devoted to antifoggants, chemical sensitizers and other emulsion addenda from the synthetic point of view. In the polymer field, the scope has been very broad, ranging from work on film supports having better characteristics—which of course are under constant investigation—to photosensitive polymers for use as resists, and other applications. Work in the latter field has recently led to materials of outstanding properties, and one of these will be offered to the trade as Kodak Photosensitive Resist. Materials for sizing paper, for use in the manufacture of baryta, which is coated on paper for photographic use, have also received attention from this department.

The field of activity of the Physics Division, is also very broad. Over many years work has been done on the graininess-granularity relationship of photographic images. Granularity may be a new term to some. It affords an objective statement whereas graininess is a subjective matter. Sharpness and acutance are similarly related. The work in the Physics Division on these two characteristics of photographic prints has led to very useful results, in that we can now measure granularity and obtain values which are in good agreement with results obtained from a large number of observers. Similarly, sharpness can be measured; the results correspond very well with judgments of observers, with of course much less effort and in much shorter time. In addition, it has been possible, in the case of sharpness, to reproducibly classify materials on which a group of observers could not agree on differences, some members showing preference for one, and some for another. This work has obviously taken a long time, but the fundamental nature of the results is, we believe, very much worth while.

There is also the problem of static in connection with photographic materials, and this probably is better known to no one than those engaged in aerial photography. A section of the Physics Division is devoted to studying the static problem as it relates to photographic materials.

Sensitometry of course is a wide field, embracing both black-and-white and color materials and processes. I believe it can be safely said that the Sensitome-
try Department of the Physics Division has contributed more to this subject than any other single group working in the field. The use of sensitometry is now well established in many applications of photography, notably in the professional motion picture industry, where it has been used for the control of black-and-white film processes for many years. With the introduction of color film to the big screen, color sensitometry, although much more complicated has been found a necessity if adequate control is to be maintained.

The practice of sensitometry on a small scale presents no serious problems, but when a large number of samples are to be handled, mechanized equipment with electronic components is required. Such apparatus has been designed and built by the Physics Division of the Laboratories, and has found wide application. We can now read and plot a hundred sensitometric strips automatically in about the time previously required to read and plot two or three strips by the older meticulous and very monotonous hand and eye methods.

A small section of the Physics Division devoted to the field of optics has made significant contributions not only to the design of lenses for special uses but in the evolution of methods for ray tracing and lens calculation. One member of this group has nearly finished a book on this subject which we believe will be an outstanding contribution.

Another long-term problem in the Physics Division has been tone reproduction in black-and-white photographs. New methods in this field have led to significant results of outstanding utility. More recently, a similar study has been undertaken in connection with tone reproduction in color photography.

Sound recording has been of interest to the Physics Division for many years. All of the testing of sound films for the operating departments is done in this division because we have the necessary equipment and adequately trained personnel.

The x-ray field has been of very definite importance of course from the standpoint of relation between the apparatus and films available and the photographic results which can be obtained. The group working in the field of radiography has made significant contributions, not only to the techniques employed in medical radiography but in connection with the development of new products and procedures in industrial radiography.

Members of the staff of the Physics Division have cooperated with those of the Emulsion Research Division in the development of new types of photographic materials for use in nuclear physics. In addition, members of this Division have studied photographic monitoring of x-ray exposure and radioactive materials, such as fission products.

The electron microscopy and spectrographic analyses are now done in the Physics Division, frequently on materials prepared by other divisions; this is being carried on largely as a service to the remainder of the Laboratories. However, in addition, experimental investigations are being made using electron microscopy in such problems as the adsorption of gelatin to silver halide and related problems.

Work on optical filters, both from the standpoint of developing new filters and preparation of special filters, wedges and step-tablets, is being done by a group in the Physics Division. Safelights of course are also the subject of frequent study by this group where improvements in characteristics appear possible.

The most recent addition to the Physics Division has been a group working in the field of television. Our interest is primarily concerned with the behavior of photographic films in television transmission and in kinescope recording. In the black-and-white field, I believe that significant contributions have been
made by this group through the use of a black-and-white television chain, which has been in the Laboratories for several years. As a byproduct of this work, it was found that using an infrared-absorbing filter on the mosaic of a black-and-white television camera yielded higher quality results. This device has now been adopted by many of the commercial television transmitters in this country. Early in 1953 we installed a color television chain, which has been operating quite satisfactorily for some months; we are beginning to study the properties of our color photographic films through the use of this color television equipment.

This reviews briefly the work of the various divisions of the Laboratories, as far as their scientific and technical activities are concerned. However, there are such mundane but important items as employment service, laboratory supplies, distribution of salaries—a matter of some importance to many of the staff—janitor service, maintenance, shops for constructing apparatus and the matter of budgets. These are handled by the Business Manager of the Laboratories and his staff, and constitute a fairly complex operation. A multiplicity of things must be done to keep an industrial research organization running smoothly besides making experiments and writing reports.

The Director and his assistant whose function is not very clearly defined, who attempt to keep what appears to them the proper emphasis and relationships among the various programs upon which work is being done, to try to catalyze new ideas, to offer encouragement when work is going poorly and to share in the enthusiasm of an important, successful experiment. It is also their responsibility to plan for the future and try to keep the Management informed, the Sales Department restive, and the production departments in a state of mild indigestion.

The organization within the divisions consists of division heads, who obviously are part of the administration group, each of whom now has a staff larger than the entire laboratory 25 years ago. There are department heads and group leaders with administrative responsibility. Within this structure of course is the one large group doing the experimental work. From this group the majority of the ideas arise, and it is through their efforts that new products are developed, new processes evolved, and improvements in photography are made.

It seems appropriate to discuss at least briefly the relation of the work of the Kodak Research Laboratories to the field with which you are more directly concerned, namely, photogrammetry.

In discussing the work of the Kodak Research Laboratories, I mentioned that in the Chemistry Division work was being done on film supports and measurements of their characteristics. I also stated that the Physics Division has made considerable progress in determining the graininess in objective terms, called granularity, and in the evaluation of sharpness, objectively called acutance. Further, in the Emulsion Research Division, I mentioned a constant effort to increase the sensitivity and decrease the graininess of photographic emulsions, and to provide materials for varieties of purposes that have the most suitable sensitometric characteristics. For the field of photogrammetry we choose from this work those items which we feel are most pertinent and consider the problems which are presented to the photogrammetrists in relation to the work of the Laboratories as a whole.

Toward this end, we have attempted to increase the dimensional stability of film support to as great an extent as we have been able, to decrease to a minimum its tendency toward static, and to provide the sensitometric characteristics which give the type of gradation most suitable for use in your work. In addition, we realize the importance of sharpness in the aerial photographs used in the
various branches of photogrammetry, and it is our aim to afford the maximum in this characteristic. There still remain definite problems in the relationship between sharpness or acutance and resolving power which have not been thoroughly worked out. These problems are under investigation in the Physics Division and in the Emulsion Research Division of the Laboratories at the present time. As new data are obtained and the importance of the variables becomes more apparent, the results will be published.

Processing photographic emulsions is largely the province of the Black-and-White Photography Division, although the evaluation of the results comes into the program of the Physics Division. This is true for all of the photographic products, and specifically those used in photogrammetry. It is our endeavor to afford to photogrammetrists the optimum developers and to present the recommendations for maximum utility of such developers as we offer.

Having obtained a photographic negative which is the best we can make available at this time, there is of course for some purposes the necessity of preparing large black-and-white transparencies, often in stereo. Here the matter of tone reproduction is considered by the Physics Division and the Emulsion Research Division, so that optimum relationships can be obtained for drawing maps and for other uses. The emulsions used on photographic papers from which prints are made also come under examination from the standpoint of affording maximum information to the photogrammetrists, and have been the subject of work to obtain the best results that we know how to achieve at this time.

We are mindful of the importance of photogrammetry as a branch of photography, and it is our intention to continue our investigations with specific reference to this field so that we may, insofar as possible, contribute to the advances of photogrammetry as it increases in its utility for various types of work. On the other hand, we can do this most effectively only if we have the confidence and the support of the photogrammetrists themselves. While members of our staff are highly skilled in emulsion making and processing, as well as being highly trained in sensitometry and the measurement of physical aspects of photographic images, we unfortunately cannot be experts in all fields; therefore, we depend on those employing photographic materials in the rather specialized field of photogrammetry to indicate to us the deficiencies, or, possibly in a more helpful manner, to tell us in what characteristics improvement might be made, so that we may tackle these problems more intelligently and make available the best materials for your use. We like to consider the cooperation with photogrammetrists and any assistance which we can give them in the field of photography, as part of the work of the Kodak Research Laboratories.

NEWS NOTE

Wallace & Tiernan—Novadel Agene Merger Announced

On January 1, 1954, the merger of the associated companies, Wallace and Tiernan Co. Inc. and Novadel-Agene Corporation, into a single organization known as Wallace & Tiernan Incorporated was completed.

The new company's principal lines of activity include: Wallace & Tiernan chlorinators, water purification apparatus, chemical feeders and materials handling equipment, processes for treating fresh produce, electrical specialties, lighthouse equipment, precision pressure sensitive instruments and ethical pharmaceuticals; Novadel organic peroxides and equipment and processes for treating flour; Richmond sifters and separating equipment; Hardesty fatty acids and plasticizers; Thomson bakers equipment; and Electro Rust-Proofing cathodic protection services.