APPLICATIONS OF VARIABLE CONTRAST PAPERS TO AERIAL PHOTO RECONNAISSANCE*

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AS A background for this paper, a brief history of the evolution of contrast control in photographic printing materials is presented.

The first attempt at contrast control in the emulsion coating was revealed in a patent by Rudolph Fischer in 1912. This patent described the idea of coating a base with two emulsions; the first sensitive to blue and green and of soft gradation, and superposed on this an emulsion sensitive to blue only and of hard gradation. The resulting product, though of brilliant conception, did not perform well. The two end gradations were very good, but the intermediate gradations produced prints of poor quality. Sensitometric studies of these results showed the emulsion to have a broken H & D curve in the intermediate gradation region accounting for the poor quality prints.

In 1937 F. F. Renwick of Ilford Ltd., England, was granted patents on a greatly improved variation of the Fischer method. Renwick mixed a chloride emulsion of hard gradation with a bromide emulsion of soft gradation. The bromide emulsion was sensitive to blue while the chloride was sensitized to green. Since there was very little overlap in sensitivities, the earlier troubles with the Fischer method were not perceptible. This type of variable contrast paper is still being produced by the Ilford Company under the name "Multigrade."

The Defender Photo Supply Company (later acquired by DuPont) introduced a still different type of variable contrast paper called "Varigam" in August of 1940. Rowland S. Potter and Seward Hagaman, originators of the new product had discovered a new series of sensitizing dyes which would sensitize a single emulsion to respond with high contrast when exposed with blue light and with soft contrast when exposed with green. This paper has been marketed here since 1940 and was used by the U. S. Air Force to a small extent during World War II.

During 1950, the Air Force began an intensive investigation of photographic printing papers which included the variable contrast type. This study was sparked by firm demands for greatly improved quality of aerial reconnaisance photographs along with very high rates of production of those photos. As the equipment for accomplishing these gains began to materialize and results of field trials were studied, it became obvious that a variable contrast paper was essential to the attainment of the new goals for quality and speed.

Before proceeding with the specific applications of this type of paper to printing operations, a brief glimpse of the rather revolutionary changes which are taking place in USAF photo laboratories seems appropriate. Studies of the reconnaissance photography of the last war as produced in the field reveal average production times of 24 to 48 hours time in the laboratory; average resolution of from 10 to 12 lines per millimeter; and lower than acceptable average quality. Print rejection and reprint rates were high as was waste of materials. The entire chain of operations in the production of finished prints was examined for weak links. The new goals were established. Average production time was set at from 5 to 10 hours; resolution as high as possible; quality level equal to or better than trade commercial photography; and positive improvements in all other factors.

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The high-capacity production laboratories of tomorrow will be radically different from those of today. The hand method of print production, sheet by sheet, will be replaced by roll type printers. Paper and film rolls will be processed in continuous processors and dried simultaneously. The old bugaboo of equipment getting complicated has been faced and it is believed to be licked. Printers and processors are rugged machines designed for field operation and maintenance.

The efficiency of the new roll-type equipment will be monitored by a system of Process Control Sensitometry developed for field use. The equipment consists essentially of a small sensitometer and a processor for sensitometric strips. In a simple manner, the speed, contrast and fog of films or papers can be measured; the replenishment rate necessary to maintain uniform contrast and density of negatives and prints can be determined.

Air Force laboratory structures are also undergoing changes. Permanent-type laboratories for the high capacity production units, such as Reconnaissance Technical Squadrons, are being built at bases in this country. These buildings are designed for efficient use as photographic laboratories. For mobile operation, where rapid moves are necessary by both road and air means of transportation, a set of air conditioned trailers has been developed that can be hauled over the roads or flown from base to base in transport airplanes. This type of trailer will contain the roll type printing and processing equipment installed for operation. In combination with field generators, water supply equipment and additional shelters, field operation at high efficiency is expected.

With this brief picture of the new type photo production units in mind, the part played by variable contrast papers in this system will be discussed.

The problems that face Air Force laboratories in connection with printing aerial reconnaissance negatives are, for the great part, identical with those of the commercial or professional photographer. Acceptable quality prints must be produced from negatives which vary in contrast or density range. Within one roll of negatives, changes in type of terrain or in lighting conditions often cause these differences in negatives. The response characteristics of variable contrast paper cause the paper to change in contrast as the color of the printing light is changed from blue to green (or yellow). This permits the operator to change the color of the light (by changing filters) before printing each negative. With conventional graded papers he must choose one from four or six different papers, each with one fixed contrast, to print each negative. The necessity for variable contrast papers with Air Force roll-type printers using 1,000-foot rolls of paper immediately becomes obvious. It is relatively impossible to pre-select one grade of fixed contrast paper which will give acceptable print quality from negatives that are of different contrast (density range). Since it is impossible to change to a different grade of paper each time a negative of different density range must be printed in these printers which use 1,000-foot rolls of paper, the paper must be capable of readily changing its contrast to fit all different types of negatives. The range of contrasts available with variable contrast paper is shown in Figure 1 and the range of contrasts available with the four grades of conventional printing papers is shown in Figure 2.

There are five different types of U. S. Air Force photographic printers. These must be modified in different ways in order to handle variable contrast papers. The five types of Air Force printers are

Type *A*—Contrast, cut sheet
Type *B*—Projection, cut sheet
Type *C*—Contact, roll, continuous
Type *D*—Contact, roll, step and repeat
Type *E*—Projection, roll, step and repeat

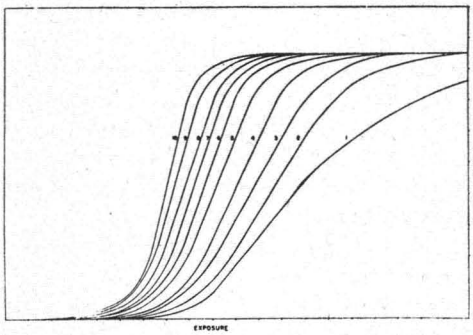

FIG. 1. Contrast Range of Variable Contrast Paper.

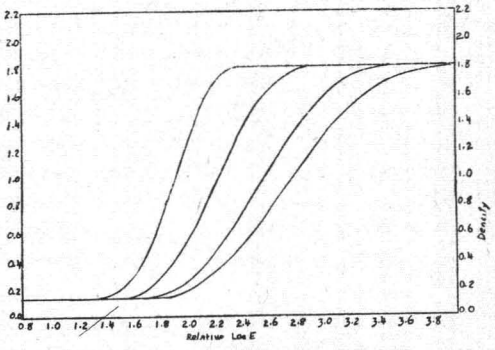

FIG. 2. Contrast Range of Conventional Graded Papers.

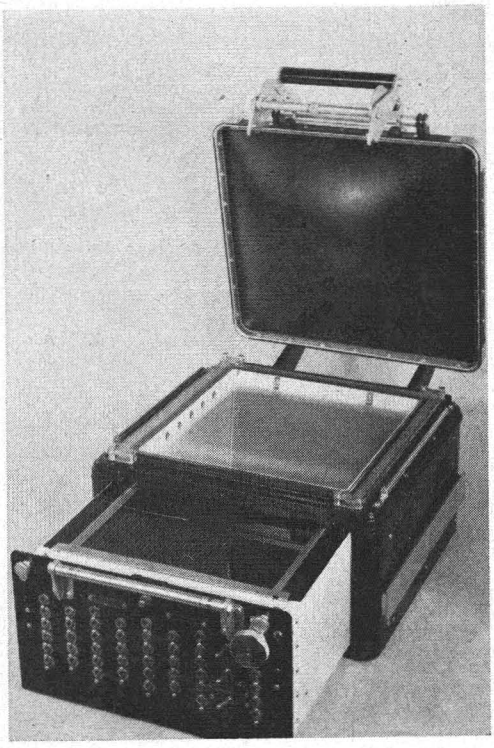

FIG. 3. USAF Type *A*-14*A* Contact Printer Equipped With Striated Filter.

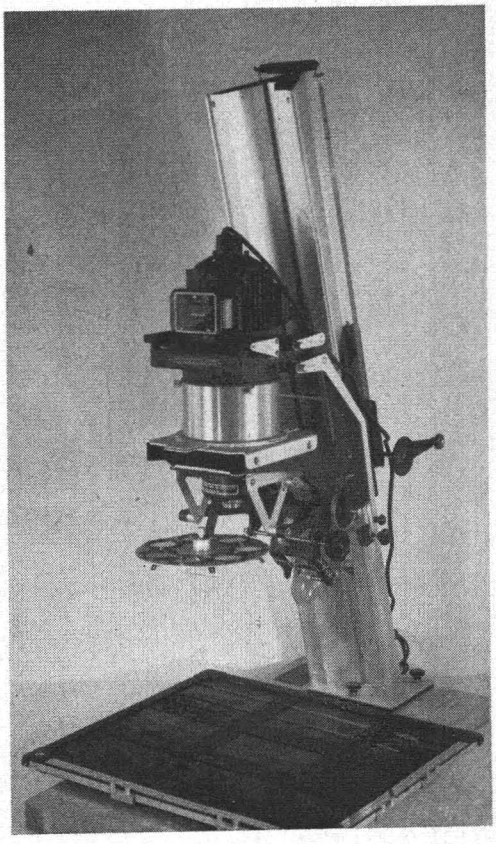

FIG. 4. USAF Type *B*-15*A* Projection Printer Equipped With Filter Wheel.

The method of application of variable contrast paper to each type will be described.

Figure 3 shows the Air Force Type *A*-14*A* printer adapted for use with variable contrast paper. The adapter kit consists of a striated filter, installation parts, and a set of tungsten bulbs of 3-watt size.

After installation of the filter kit, the operator changes the color of the printing light by turning a control knob on the front of the printer. This moves one filter with alternate blue and yellow filter stripes on a glass plate over a second glass plate carrying alternate opaque and clear stripes. As the plate with the color stripes moves over the shutter plate, either all blue light, all yellow light, or any proportionate mixture of the two is transmitted to the sensitized material.

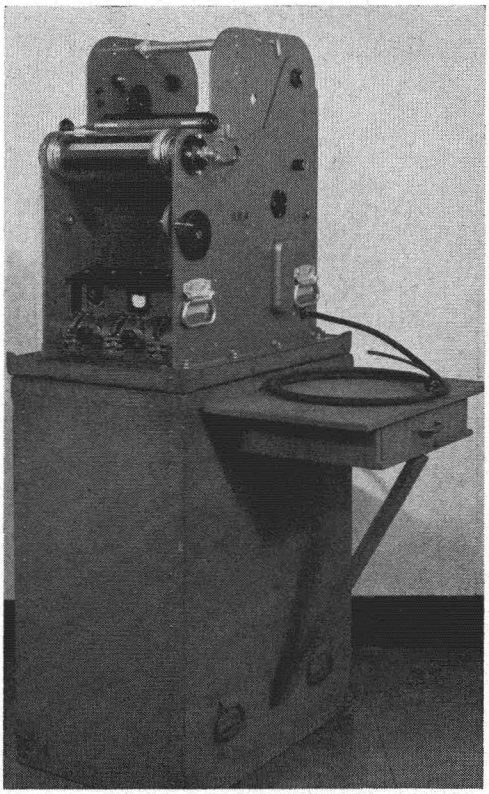

FIG. 5. USAF Type *C*-1*B* Continuous Printer.

Figure 4 shows the Type *B*-15*A* projection printer equipped with a filter wheel which carries up to 10 different filters ranging from blue to yellow. The operator rotates the wheel to select the color filter needed to produce the desired contrast response from the variable contrast paper.

Figure 5 shows the Air Force Type *C*-1*B* printer. The accessory equipment designed to permit the use of variable contrast materials with this printer is not yet in production. In principle, two separate lamps—one filtered blue and the other yellow—each direct light into the printer aperture. A separate control box, to be used beside the printer, contains counter-opposed rheostats. The operator turns a single control knob to effect a simultaneous increase in voltage on one lamp and a decrease on the other. This change in color is effected without materially changing the over-all intensity of the printing light. In a continuous manner he can change the color of the printing light as he sees negatives of different contrast enter the printer over the viewing roller.

Figure 6 diagrammatically shows the Type *D*-1 printer. In a semi-automatic manner this printer contact prints 9″×9″ or 9″×18″ negatives onto 1,000-foot rolls of paper at rates of up to 20 prints per minute. The printing head contains a striated filter which is manually operated as was described for the *A*-Type printers to cause desired contrast change with variable contrast papers.

The experimental model of the Type *E*-1 printer is shown in Figure 7. In a similar mode of operation to that of the *D*-1 printer, the *E*-1 also prints at a rate of up to 20 per minute 9″×9″ prints, though by projection, from any of four different sizes of negatives. By means of different lenses, the *E*-1 will make prints

from either single or double frame 35 mm. negatives or from 70 mm. or 5-inch camera negatives. The small box sitting on the right side of the printer has five push buttons which are numbered to correspond with five different filters which are inserted automatically in the printer light path when the button is depressed. In the production versions of this printer the push buttons will be located on the right hand panel. Contrast control is thus achieved by the operator as he

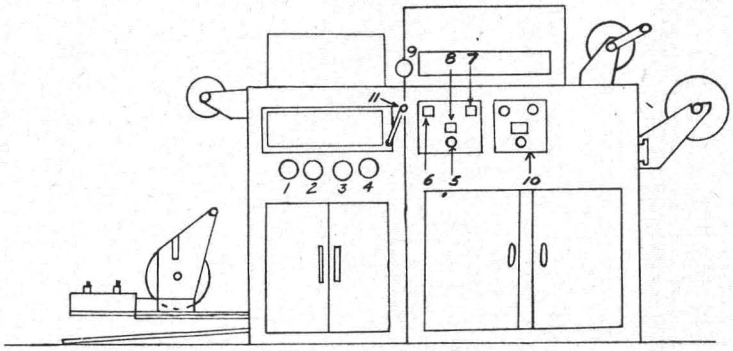

FIG. 6. USAF Type *D*-1 Contact Printer.

views each negative before setting into the printer the number of prints desired and starting the printing operation. The paper capacity of the *E*-1 is $9\frac{3}{8}'' \times 1{,}000$-foot rolls.

One type of variable contrast paper, "Varigam" has been available to service organizations in limited quantities for the past two years. Considering that it could be used only on the *B*-Type cut-sheet projection printers, the effect on field units has been only one of familiarization and training. Extensive field tests on the experimental *D* and *E* type printers have been in progress for one year using two different types of variable contrast emulsions coated on water-resistant base. The second type is an experimental paper submitted by the Eastman Kodak Company for evaluation. The main objectives of these tests are:

1. To evaluate relative merits of conventional graded papers and variable contrast papers.
2. To determine the type of variable contrast paper best suited to aerial reconnaissance photography.
3. To develop satisfactory means of contrast control on roll-type printers.

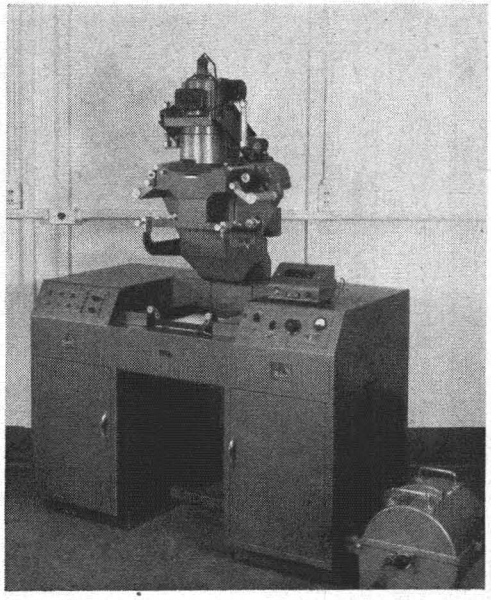

FIG. 7. USAF Type *E*-1 Projection Printer.

As these tests are not now complete, the preliminary information discussed here must be considered as an interim report of progress. As the results of this work to date are surveyed, it must be kept in mind that only the final report on this study will completely satisfy the main objectives stated earlier.

Concerning the comparison between conventional graded papers and variable contrast papers, those in the field organization performing experimental tests on a large scale have indicated a strong preference for the variable contrast type. They further state that on roll-type printers this type of printing paper is an absolute necessity if finished quality prints are to be produced. The photo interpreters who have studied the large mass of prints produced during this project prefer prints on variable contrast paper for reasons of equal or better image quality and for uniformity of print quality and image color. The testing organization claims more economical use with these new papers and higher efficiency through less waste and fewer reprints. Training new operators in the use of variable contrast papers in the roll-type equipment was reported to be less of a problem than with conventional graded papers.

It appears an absolute certainty that the Air Force will use variable contrast papers in roll-type printers. Because of the many other requirements not covered in this paper which will always exist for fixed contrast papers, it appears equally certain that the conventional graded papers will not be replaced, at least not within the foreseeable future. The very important question which has not been answered concerns which type of this new paper will be adopted. The comparative tests of the two types mentioned are incomplete. Discussion of the technical differences between these papers has not been permitted at this time. It may be said that the two papers are Dupont's "Varigam" and an experimental paper submitted for evaluation by the Eastman Kodak Company. It may also be said that both papers reproduce aerial reconnaissance photographs in an acceptable manner. As a matter of information, the Eastman paper has reversed sensitivity to the DuPont paper. The Eastman paper responds with its lowest contrast to blue light whereas the "Varigam" paper responds with its highest contrast when exposed with blue light. In addition to the factor of reversed sensitivity there are several other important reasons why there should be only one paper of this type to receive Air Force standardization. Most important are those of economy and uniformity. Undoubtedly the simplified training problems of one paper over two papers as well as differences in performance characteristics of the two papers will play important roles in the final decision. Liaison with the Army and the Navy must be pressed and is highly encouraged.

As a direct result of the achievements of aerial reconnaissance photography during the last war, photography has been recognized as a vital part of military operations. The opportunity has been given of solidifying these gains and to bring to reality the tremendous role photography can render to reconnaissance and to intelligence in general. It is believed that the application of variable contrast paper to aerial photo reconnaissance will prove to be one of the greatest steps in the realization of the objectives.