it is not a shutter which you can exchange easily. But on the other hand, the merits of the shutter are proved in that we have already destroyed three electric computing systems to get a shutter worn out. The first shutter built has now made 1,200,000 exposures without being worn out. That is because no springs are involved. We cannot build, and we cannot guarantee, such high precision lens, when it is so built that you can shift something between the lenses. We also tried to make the mount of the lens as stable as possible.

MR. BURKE (Signal Corps Engineering Laboratories): How much advance notice is necessary before the shutter will open up? What's the time interval between when the pulse comes into the shutter and the time that your final capping blade opens up?

DR. TRAGER: It may be up to one-fifteenth of a second at the lowest shutter speed.

MR. SANDERS (Aeroflex Corp.): I'm quite flabbergasted at the efficiency that you speak of. Am I correct in understanding it to be 92% at 1/1,000 of a second?

DR. TRAGER: No. 92% for 1/50 to 1/500. It is actually about 84% for the setting 1/100 to 1/1,000 of a second. But we are coming up also with this shutter type to 90% when we have installed a diaphragm to an aperture f/0.8.

MR. HARMAN: Doctor Trager, do you desire to comment on what plotting instruments have been devised for the use of this super-wide-angle lens?

DR. TRAGER: I do not have much information here because the instruments my company manufacture are for nearly all types, but especially our own types of cameras and lenses. I don't think that we will ever be able to handle Russian pictures with a German instrument in this way.

MR. PECKINPAUGH (Photogrammetry, Inc.): Why do you stop down with a diaphragm rather than go to a faster shutter speed?

DR. TRAGER: It is a question of mechanics. Working with 9,000 rounds a minute requires quite a mechanical design and I think there should be shutter limits with 1/1,000 of a second. Actually when tested in the factory the shutter shows that the highest shutter speed is already 1/1,250 of a second. But we are not claiming this speed practically. Our shutter speed should be limited right now to 1/1,000 of a second.

Mass Production of High Quality Contact Prints

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ABSTRACT: *The mass production of highest quality contact prints from aerial negatives has been realized by the introduction of electronic printing devices and mass or continuous processing equipment. The processing equipment preceded the controlled exposure instruments and was virtually useless in regard to high quality prints without the electronic equipment to provide the scanning, dodging, and exposure.*

IN SOME circles automation is an ugly word, but it has made possible the mass production of high-quality contact prints from aerial negatives. At Army Map Service mass production means 50,000 to 75,000 contact prints from 9″ by 9″ or smaller aerial negatives per month. High quality means that all of the detail in the negative from high light to shadow has been reproduced on the paper prints within the limits of present photo-sensitive media. This qualifying statement is made because there are many more tonal gradations in the negative film emulsion than are possible to reproduce on the paper emulsion due to inherent characteristics of the emulsion coatings.

The Army Map Service began an investigation in 1951 of ways and means of increasing production of paper prints through improved instrumentation, methods, and techniques. It was recognized that the photo-finishing trade had in part solved mass production. But it was apparent that there were several major differences between the photo-finishing laboratory and the photogrammetric laboratory. The first difference is in subject material.

Assuming that the aerial negative has been correctly exposed and processed, it has more than 100 tonal differences, or differences in density, some of which are not perceptible to the human eye. In addition, there are some inequalities in density due to the position of the sun or solar altitude at the instant of exposure, the flight direction, variation in reflectivity of the ground objects, atmospheric haze, industrial haze, spectral response of the emulsion, cosine fourth power law, inverse square law, veiling glare and others. Now that we have had a good look at the subject in point, the problem is how to mass-produce these prints so that most of the useable and perceptible tonal differences in the negative are retained, and most of the undesirable inequalities of density are eliminated. In the solution of this problem, AMS has taken advantage of available commercial products and improvised or modified procedures and equipment, as required. My mention of AMS use of particular commercial products does not constitute endorsement of those products by the United States Government.

Since the automatic and semi-automatic processing equipment preceded the printing equipment in development and availability, we will consider this phase of the entire process first. Processing equipment falls roughly into two categories: the first is known as continuous or roll-type processor and the second is the batch or basket-type processor. Each of these has certain advantages peculiar to the system, the particular installation needs, and the quality and quantity demands.

A continuous or roll-type processor accepts paper and/or film in a roll form in widths up to 16 inches and lengths up to 1,000 feet or more. Such a processor is fairly complicated when equipped with refrigeration, recirculation, replenishment, and filtration accessories. Because of a large number of moving parts, calibration and maintenance are of the greatest importance. At any one moment, as much as 140 lineal feet of photographic material are in the processor in some stage of development, fixing, washing, or drying. A mechanical failure can result in the loss of a major portion. In each deep tank compartment there is one or more dip rollers under which the photographic media must pass in contact with the emulsion. Any build-up of precipitate on these rollers results in damage to the image. Adjustment of the drive rollers regulates the rate of speed at which the material travels through the processor; in most instances, the rate at which the material can be dried is the controlling factor. It is not possible to compensate for variations in development in any small increment of material as there are approximately eight feet of exposed material between any two drive rollers, and the image is visible only on the tops of these rollers. One other possible disadvantage to this method is that a test strip must be run through the processor to determine the correct combination of exposure and development since identical treatment cannot be achieved in a tray or tank. There is considerable make-ready time to this operation, and a substantial amount of prints is required to justify the operation of the equipment and use of chemicals.

The other major type of processing equipment could be termed the batch or basket-type which for many years has been widely accepted in the commercial photo-finishing plants. This equipment, such as the Pako Print Machine is particularly well-suited to the larger size prints up to 8″ by 10″. This machine does not solve the mass production problem since the prints are developed by hand and by inspection. From this point on, however, the prints are mechanically transported through the various solutions and washing baths, as the baskets flip over at timed intervals.

It is advisable to consider the number of times a print or a group of 10 prints is handled in the various processing solutions if the entire operation is done by hand in tubs or trays: 1 operation into developer tray; 3 operations during development (agitation); 1 operation from developer to short stop; 1 operation from short stop to fixing bath; 3 operations during fixing bath (agitation); 1 operation from fixing bath to washing bath; 3 operations during washing (agitation or separate baths); 1 operation from washing bath to draining table; and 14 operations $\times 10$ prints $= 140$ operations exclusive of drying and sorting. This type of processing results in the best possible shuffling of the prints and necessarily the longest possible sorting time. Other undesirable aspects of this method are fairly obvious.

The type of equipment designed by Army Map Service to meet its specific requirements can be called a "basket-tank" processor. This is a seven compartment processor with an outer jacket for temperature control. Each compartment holds ten U.S. gallons of solution. The first contains the developing solution; the next two, the first and second fixing baths; the fourth is a running water rinse; the fifth contains a chemical eliminator or stabilizer; and the last two compartments are for final washing. The prints are loaded into a type 316 stainless steel rack or basket, back to back, 50 prints in each rack in the order in which they were printed or exposed. Development is controlled by inspecting the two outer prints in the rack and is nominally one and one-half minutes at 68 degrees Fahrenheit. The time in each of the other six compartments is three minutes; accordingly the entire processing time for a rack of 50 prints is $19\frac{1}{2}$ minutes. The processor has a potential output of 50 prints every three minutes or a rate of 14 feet per minute. These prints meet 30 year permanency tests, and the processor will accept any weight and surface photo paper. The rinse and washing baths are at the rate of six G.P.M., and for the first time the prints are truly suspended independently of each other and receive the full benefit of the chemical and washing action. There is a fairly accurate balance between the fixing, stabilizing and washing times. There are no replenishment, filtration, or re-circulation accessories with this processor. Since each compartment holds only a relatively small amount of chemicals (10 gallons) and each chemical used has a different depletion rate, the racks are tagged well before the exhaustion point is reached, so that the solutions can be drained by the external valves and refilled with a portable pump type mixer-distributor in a few seconds. Due to the simplicity of design, there is virtually no maintenance in connection with the operation. Including the loading of the baskets the operation is performed by one man; he is the quality control of the entire process.

In this method the individual prints are handled only twice: once when loaded into the racks and once when removed from the racks and run through the driers. As a group of fifty prints, they are handled seven times. The ratio of print handling is then approximately 1:7 compared to the tray or tub method. Other time-saving aspects are that the processing operation can continue to the actual close of the work day, the last rack entering the processor just 20 minutes earlier. Prints which have been exposed, but not processed can be stored in the racks in a light-tight compartment or in covered boxes, for processing the next day. All compartments are drained and flushed at the close of operations. The make-ready time next morning is less than five minutes. The overflow from the three washing compartments into the outer jacket provides the necessary temperature control during development for consistent results.

This entire method assumes that each print in the rack of 50 has received the correct exposure and dodging so that individual attention to each print is not necessary. It should be noted that the test print received the identical treatment as the mass produced prints, and this determination was made in one and one-half minutes.

Now we come to the printing or exposing equipment which made the mass processing possible. The electronic printing devices can be placed roughly in two categories. The first uses a relay mechanism in which the negative is scanned in one part of the machine and the lighting pattern, as well as the exposure increment, is established in another part. This is sometimes romantically referred to as a "memory device," and is usually quite complicated. The second type of electronic printer employs a simultaneous scanning, dodging, and exposure by passing a controlled beam of light through the negative and printing media. Such a printer is the "Log-Etronic CP 10 S."* To avoid repetition of technical data, remarks in this paper will be confined to actual operational aspects or performance characteristics.

The Log-Etronic printer will accommodate roll or cut film in sizes up to 10″ by 10″. The X and Y amplitude of the scanning roster should be fairly accurately adjusted to the negative size to effect minimum exposure times. The exposure index dial can be set at 30 for double-weight paper or 60 for single-weight paper, for the first test print. These settings would be somewhat influenced by the apparent density of the negative. The edge density of the selected mask should very closely approximate the average negative density. This mask must be accurately placed and taped on the back edge of the printing surface so that the clear portion of the mask exactly fits the negative size. The importance of this particular operation cannot be overemphasized if best results are to be obtained, because with any light leaks between the mask and the negative, or if the edge density of the mask and negative differ considerably, the resulting print will have either a light or dark border zone within the image area of the negative since the scanning device will average the differences in the two densities.

The next step is to place the photographic paper on the negative, emulsion to emulsion (for contact prints), and lower the platen. When the platen closes, the exposure is begun, and the scanning and exposing spot moves over the negative. The total exposure is integrated in terms of the lineal setting on the exposure index dial. This setting is not expressed in terms of seconds or any increment of time, but is a unit lineal value. When the photo multiplier cell has integrated or added up the total exposure in terms of the dial setting, the printing light is automatically turned off. The platen is raised, and the exposed print is removed and processed in the customary manner. The operator of the processor will tell the printer operator to increase or decrease the exposure index if he considers the test print too light or too dark, and may recommend a different grade of contrast paper. If the initial test was too far off, a second test print may be prepared since, on a basis of this test, several hundred or thousand prints will be made before the operator sees them again.

Selection of the proper contrast of printing paper brings up a very interesting aspect of this system of electronic printing. If the "Log-Etronic" principle is examined from the technical aspect, we find that the size of the scanning and printing spot of light is approximately $\frac{1}{2}$ inch in diameter and is projected from the face of the cathode ray tube through a simple lens to the negative plane. Some of this light passes through both the negative density and the printing medium and registers on the photo multiplier tube situated above the negative. The signal that the photo multiplier tube receives is first amplified, and then passed by an inverse feed-back system to the cathode ray tube. Thus the spot of light immediately gets brighter or dimmer according to the negative density. The spot is small compared to the negative area, but large compared to the detail in the negative. This relationship produces an unsharp mask effect on the print which is a compression of the D log E curve (or H and D curve). If the total density range of the negative has been greatly compressed, the selection of the contrast grade of printing paper significantly loses its previous importance. The Army Map Service buys only two contrast grades of paper, and a considerable variety of negatives is accommodated by these two grades which are considered normal grades, #2 and #3.

At the present the Army Map Service is using an experimental emulsion coating prepared by the Kodak Company. This is about three times faster than Kodabromide having a peak sensitivity of 4,600 angstrom units to match the light source of the cathode ray tube. The paper is supplied in two contrast grades, both of which will accommodate a fairly wide range of negative conditions. The increased speed is of secondary importance as far as dodging is concerned, since the manufacturer of the printer believes that ten seconds is the minimum in which this operation can be successfully accomplished. The increased speed is of value, however, when fairly dense negatives are encountered. Even with negatives of normal density, it

* PHOTOGRAMMETRIC ENGINEERING, Vol. XXI, No. 4.

presents the advantage of allowing smaller printing apertures. The ultimate goal in a special purpose paper for electronic printing would be to reduce from two to one the number of grades that would produce an ideal print from the entire range of negative contrasts and densities.

It must be pointed out in conclusion that the Log-Etronic Printer is not a high-speed printer. The gain in production is achieved by a proper ratio of printers to processors and efficient employee utilization and equipment. A striking example is the fact that the printing time each day for each operator was increased from four hours to nearly eight hours.

Electronic printing has made possible gains in quality that even the most experienced photographer could not duplicate. It has made possible a rapid expansion of production facilities to meet emergencies and also the use of relatively untrained personnel in a formerly skilled craft. It is definitely here to stay.

Discussion of Mr. Knibiehly's Paper

MR. HARMAN: Are there any questions?

MR. LUDWIG (Industrial Photog.): I am curious about the necessity of testing prior to each run.

MR. KNIBIEHLY: A test print does not have to be made on each run. It is prepared on a basis of printing a particular roll of negatives. The operator evaluates the next roll of negatives. If it falls within the range of densities for the first roll, he does not make another test print. The exposure control is automatic to a fairly wide range of densities.

MR. JOHN ROWE (Department of Highways, Ohio): What is your experience with the Log-Etronic printer in regard to repairs or breakdown?

MR. KNIBIEHLY: Since A.M.S. was one of the first Government agencies to use this type of equipment, fairly accurate records have been kept. These show that perhaps less than 1/10 of 1% total operating time has been devoted to repair or maintenance. This assumes intelligent operation. While certain skills of the photographer have been eliminated, others have been added which require the photographer to watch closely to determine that the equipment is functioning properly and to make small adjustments, for instance, in the amplitude of the scanning roster or the frequency of the scan to keep the printer operating at peak performance.

MR. VICTOR ELLIS (commercial camera designer, Montclair, N. J.): Can a corrected master negative be produced by the Log-Etronic printer?

MR. KNIBIEHLY: Yes indeed. From a given negative we have produced a master positive in which the scanning and dodging has been accomplished. From that positive a duplicate negative was made by conventional methods, and multiple prints run from that negative. If the duplicate positive which was produced electronically was again printed electronically to the negative, the result would show over-correction. The photograph, continuous tone, would begin to approach the characteristics of a line negative through this over-correction of scanning and dodging. I am told that if the size of the scanning and printing spot were decreased, we could actually obtain a line image from a continuous-tone negative.

MR. EARL ROGERS (U. S. Forest Service): Have you or anybody else had any experience in the use of the electronic printer with color photography or infrared?

MR. KNIBIEHLY. Personally no.

MR. TUPPER: I assume you mean printing from a color original onto a color intermediate or duplicate material. The cathode ray screen is of limited spectral range and primarily blue emission. I therefore believe it would be difficult to print from color to color, with the electronic printer as now designed. Of course, the problem with infrared photography, in which the image is in black and white, is no different than with conventional panchromatic photography.

MR. BURKE (Signal Corps Lab.): You indicated that the third processor had a theoretical rate of 50 prints per three minutes. Does that include the operation of loading the holders?

MR. KNIBIEHLY: Yes, since the development time is approximately ninety seconds, approximately a minute and a half is available for loading the next basket, to provide agitation in the baskets which are present in the processor. So actually the processor has a potential of 50 prints each three minutes when run by an efficient man.

MR. BOSWORTH (West Palm Beach): Will the agitation of solutions solve the same problem as agitation of the baskets?

MR. KNIBIEHLY: Yes. Since we were interested in designing this processor with the utmost of simplicity, we did not provide any mechanical agitation, such as recirculation of the solutions. The agitation of the prints in the baskets is very simple; it's a lateral motion and at least from performance tests seems to provide adequate agitation. This needs to be done only intermittently.

Proposal for the Miniaturization of Aerial Photography

GOMER T. MCNEIL,
Photogrammetry, Inc.

ABSTRACT: *The proposed system represents an attempt to eliminate the objections of paper prints and to introduce further substantial advantages not offset by corresponding qualitative disadvantages. The proposal does not mean to imply that the days of the paper print are numbered; on the contrary, the use of paper prints will probably increase in certain directions where they will function with undisputed advantage.*

INTRODUCTION

MANY contributions to science and engineering have been developed by men who believed in the concept of fully utilizing the unique combination of existing facts. Technical proposals usually outline an integrated system of elemental components or building blocks. Upon close analysis, it will usually be found that very few, if any, components within a proposal are basically new. The components supporting this proposal for the miniaturization of aerial photography are no exception.

GOMER T. MCNEIL

Two of the more salient requirements confronting field officers responsible for aerial photographic intelligence are:

(a) to secure sufficient intelligence of the area under their cognizance, and
(b) once the intelligence is obtained, to effect its widest distribution among the personnel about to engage in an operation.

THE PROBLEMS OF AERIAL INTELLIGENCE DISSEMINATION

The general dissemination of aerial intelligence is beset with certain obstacles:

(a) the comprehensive installations required for mass production of paper prints,
(b) the inadequacy of the 9×9-inch print as an object to be viewed by many individuals at a time,