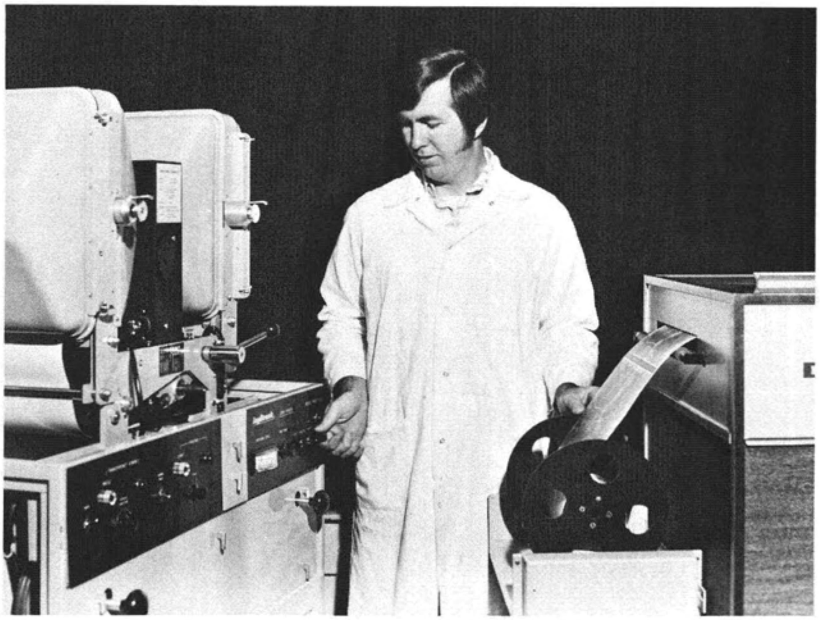

FIG. 1. LogEtronic SP 10/70 printer *(left)* and Kodak Versamat *(right)*.

RAY J. MEEHAN, President
Atlantic Aerial Surveys, Inc.
Huntsville, AL 35801

Increasing Productivity In Photogrammetry

In today's economic climate, management is pressed to find ways of increasing the productivity of its people with equal or better quality of service.

(Abstract on next page)

THE MANAGEMENT of a commercial photogrammetry firm has essentially the same basic objectives as any other business organization: healthy growth in sales and profit by providing a good product at a fair price. To do so, the firm must invest in the equipment and must carry the labor overhead that are necessary to maintain quality of service as volume expands. The cost can be particularly burdensome in photogrammetry because much of the specialized equipment is so expensive and, more important, the people who operate it command such high salaries. In today's economic climate, management is therefore pressed more than ever to find ways of increasing the productivity of its people with equal or better quality of service.

In our experience at Atlantic Aerial Surveys, automation can play a major role in accomplishing these objectives. Although it is a word that has been given many definitions, the one that applies best in photogrammetry describes automation as the mechanizing of all those operations that can be done as well or better by specialized equipment so that human perceptions and skills can be applied more in the operations that machines cannot do at all. However capable the device, the human eye and human judgment will always be needed at a stereoplotter. But an automatic processor can develop, fix, wash and dry more photographic paper or film in an eight-hour shift than the most capable technician—and, as long as there is adequate volume, do it at a far lower unit cost. Automation can also improve quality control in that it can provide better, more consistent aerial images wherever they have to be used.

In two quite different areas automation has significantly increased productivity. First, automated equipment is used for developing roll film and paper and for exposing paper through aerial negatives, both with a minimum of human attention. Second, various data-reduction devices are used to handle the vast amount of photogrammetric data that are generated, and a computer performs many of the more complex computations that were once done manually with the help of desk calculators.

The improvements in quality control have to do with the various forms of images in photogrammetry and in the accuracy of the calculations. Through point-to-point automatic dodging, electronic printers provide the superior contrast control that is particularly important in aerial photos that are matched in groups, such as mosaics and indexes. The improved detail that modulated electronic printing provides in both highlight and shadow areas of an aerial view leads to easier, more definitive photo interpretation in such work as volumetric calculations of stockpiles and full analytical aerotriangulation. Automated data-handling equipment and the computer increase accuracy, of course, by reducing the potential effect of human error, especially in performing the same calculations over and over again.

Increasing Productivity

Two of the major pieces of equipment in the Photo Lab are the Kodak Versamat film/paper processor (Figure 1, right) and the LogEtronic SP10/70C electronic strip printer (left). Rolls of black-and-white aerial film negatives are developed in the processor, roll paper is exposed in the strip printer, and the prints are then developed in the Versamat processor.

The speed of the processor ranges between 12 and 14 ft/min for film or paper, completing a 250-ft roll in somewhat less than 20 minutes. The SP10/70C printer, which exposes paper through normal negatives at between 36 and 40 ft/min, takes between 6 and 7 minutes to print a roll. The film/paper processor can be used with the same chemistry for both film negatives and paper simply by changing the content of potassium bromide in the developer and the replenishment rate of the developer and fixer. However, if the volume of work is large enough, one processor is used for negatives and a second for paper prints.

The increase in productivity achieved with the processor and strip printer is substantial. In our experience, the combination of the LogE strip printer and automatic processor completes a roll of aerial film in about one-third the time of a conventional printer and hand processing. Compared with hand processing and an electronic printer not equipped to handle rolls, the automated equipment processes a typical roll in about half the time.

The LogEtronics SP10/70C strip printer exposes the paper through the film with a scanning spot on the face of a cathode ray tube. The intensity of the scanning spot is automatically modulated to increase the exposure in dense portions of the negative and decrease the exposure in light portions. Uniformly exposed, high-resolution prints can then be produced in large volume from rolls of aerial negatives that vary widely in contrast both between and within images. With a conventional fixed-intensity printing light

Abstract: *Atlantic Aerial Surveys, Inc. applies manpower-saving photogrammetric instruments to facilitate the production of maps and data. A Kodak Versamat film/paper processor used in conjunction with a LogE strip printer enables the printing of a roll of film in half the time needed formerly, as well as providing improved quality control. A Kern PG-2 plotter is equipped with digital readout so that the output data can be transmitted directly to a computer for determining the volumes of stockpiles. A Kern MK2 monocomparator has a punched-paper tape output to facilitate data transmission to a computer for aerotriangulation calculations.*

and hand developing, both exposure time and developing of the paper would have to be varied as the overall contrast level changes between images (contrast changes within an image, on the other hand, would require either multiple exposing lights or hand dodging, both of which are too slow for quantity work and usually unsatisfactory). With constant developing temperature and time in the automatic processor, exposure of each paper image must also be constant — a requirement that, in high volume, can be practically accomplished only with automatic contrast control.

The usual procedure before film processing in an automatic processor is first to run a standard control strip through the processor, read the density of the developed strip, and adjust developer replenishment as necessary. A test strip is then run from the paper roll and, as a result, the developer replenishment rate is changed as called for. With the contrast control provided by the electronic strip printer, however, the developing time and temperature rarely need to be changed from roll to roll.

The automated photo processing equipment also provides the capacity to complete large projects rapidly, without impairing quality or overtaxing the lab facilities. Not long ago, for example, a client requested that four areas approximately 200-300 square miles each be flown and that multiple photo reproductions be provided. Six contact prints of each negative and six copies of the photo index for each of the four areas were to be prepared. As there were about 250 exposures per area (scale of 1000 ft per inch), there were more than 6,000 contact prints involved in this assignment — and they had to be delivered within seven days. Given the assignment on Friday evening, the four areas were flown on Saturday (fortunately, the weather was good), and the order was delivered to the client on the following Friday by air. Without automated equipment in the Photo Lab, it would have been almost impossible for a commercial organization to handle such an assignment within a week at a profitable and acceptable quality level.

Improved Quality Control

Film and glass positives for stereoplotting are exposed in an electronic contact printer to achieve better tonal balance within stereo pairs. Inasmuch as the stereoplotter controls can vary intensity but not contrast, unbalanced pairs can make an already rather sensitive procedure far more difficult.

Diapositive film or glass plates are exposed in a LogEtronics Mark IV electronic contact printer (Figure 2), which in 1973 replaced a Mark II printer that the Photo Lab had used for seven years. The primary immediate advantage of the newer model was that variable dodging provides the flexibility to get the best possible results with different types of exposures, which are encountered in stockpile inventory work.

In addition, the Mark IV printer includes a

Fig. 2. Making a stockpile print on a LogEtronics Mark IV printer.

FIG. 3. Checking scale on plan-and-profile sheet on utilities map.

built-in capacity for extending electronic printing from only black-and-white to color as well. Although presently photography in color alone costs about five times as much as in black-and-white, the photographic detail for interpretation is far superior wherever vegetation is involved. Because color at present is now limited to special projects, film and paper processing is done by an outside firm specializing in color. If volume grows to the point where internal processing is economically feasible, a color cathode ray tube will be installed in the Mark IV printer.

Contrast control is particularly important if a number of prints are matched together in laying mosaics or in preparing plan-and-profile sheets (Figure 3). Comprised of a plan photo and a profile drawing, plan-and-profile sheets describe water, gas or sewer lines and other rights-of-way for engineering groups. The plan photo is usually made up of six to ten contact prints layed in a strip mosaic, copied onto one negative and reproduced on photosensitized polyester-base film by screening to produce a halftone. The screened halftones and other line film are developed in a DuPont Cronoflex ERF Processor.

In property ownership mapping, it is necessary to provide as part of the package 40 × 40-inch enlargements of selected aerial negatives. Normal procedure is to expose automatically a duplicate negative of the entire aerial roll in the electronic strip printer. Selected negatives in the automatically dodged duplicate roll are then exposed in a K&E 12× horizontal enlarger to make 5× enlarged paper prints. In this way, all the necessary contrast control is already provided in the negatives so that uniform exposure of the paper from enlargement to enlargement is assured.

In addition to the enlargements, photographs in the property ownership mapping package includes one paper contact print of each aerial frame, a positive film halftone (100-line or 133-line screen) the same size as each enlargement, and a photo index for each scale of photography. In the present ongoing mapping project for Madison County (where Huntsville is located), Atlantic Aerial Survey's Tax Mapping and Appraisal Divisions are mapping the country at four scales: 50 ft/in for business, 100 ft/in for urban, 200 ft/in for suburban, and 400 ft/in for rural sections. The main element in the mapping package is the base manuscript that records planimetric features, grids, sections, township and range lines, vegetation, and physical features.

Stockpile Inventory Calculations

Stockpile inventory calculations provide volume measurements of coal, gravel, sand, woodchips, logs and any other materials that are stored outside in very large piles. A utility, for example, typically would need to know the total volume of its coal piles four times per year for its own inventory control, and annually for its auditors. The stockpile is flown to obtain a single good stereo pair of photographs, diapositive plates are made, and

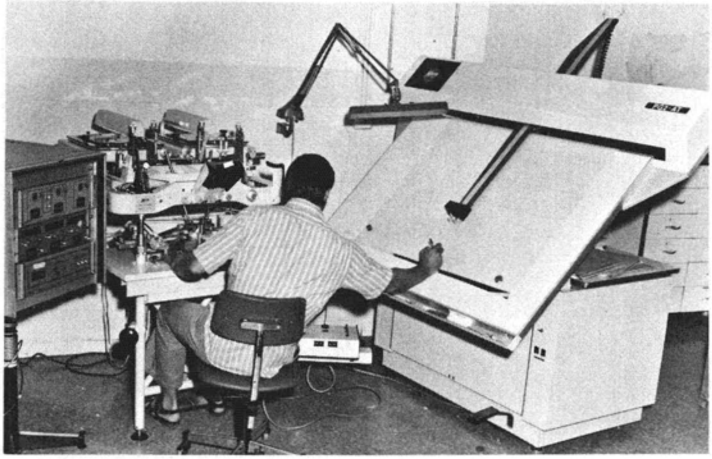

FIG. 4. Kern PG-2 stereoplotter, teletype terminal, digitizing unit consisting of Datos 303 Data Transfer System, DGC 400 Scaling Translator and a digital readout, all at one station.

the top profile of the stockpile is measured on a stereoplotter. At a compilation scale of 50 ft/in an accuracy of plus or minus 1½ per cent of total volume can be guaranteed.

The primary equipment used in stockpile calculations (Figure 4) is a Kern PG-2 Stereoplotter, a Teletype terminal, and a digitizing unit (far left in Figure 4) consisting of a Datos 303 Data Transfer System, DGC 400 Scaling Translator, and a digital readout, all in one chassis.

If the ground control has already been established (necessary, of course, only the first time that a particular stockpile is measured), the stereoplotter operator is able to detect the surface of the stockpile at any point and measure its true position and height. The volume calculation uses the average-end-area method, which requires that the operator follow the top profile of slices at the pile at regular intervals. Usual procedure is for him to follow the stockpile profile at 25-foot intervals in the *X* direction, making readings of the Z coordinate every 25 ft or at significant breaks (changes in profile) in the *Y* direction. At each reading point, the digitizing unit connected to the stereoplotter converts the *X*, *Y* and Z coordinates of its true position to digital form, which in turn is punched on standard eight-channel paper tape at the Teletype terminal.

After thus recording all reading points on the surface of the stockpile, the punched tape is entered into the Teletype terminal for transmission to a time-sharing computer in Daytona Beach, Florida. Using a proprietary computer program called *STOCKPILE*, the volume of each stockpile segment between adjacent stations is determined by calculating the cross-sectional area of each station, averaging the two end areas, and then multiplying the average end area by the *X*-direction interval between stations, in this instance 25 ft. The calculations are then automatically typed out in tabular formats including at the bottom a summation of the total volume of material in cubic feet.

In addition to measuring the top profile of each station of the stockpile, of course, calculation of the end area requires knowledge of the bottom profile. In the preferable situation in which this information is supplied by the client, the bottom profiles are entered into the computer. This may be done either from station to station or the bottom profile entered at the end of the run. The simplest condition, of course, is if the stockpile is located on a flat surface (or nearly so) so that the bottom of each station can be considered a straight line.

The time required for stockpile calculations naturally depends on the size of the pile. For the *BIG CHIP PILE* (Figure 5), a total of 404 coordinates were read, a process which took about 45 minutes once the stereo pair was in position and digitizing unit set up. The three sets of calculations (*BIG CHIP PILE*, *SMALL CHIP PILE*, and *COAL PILE*) took a total time of about 3½ hours from the first reading to completion of volume printout on the Teletype terminal. Of that time, about 30 minutes was involved in entering the punched tape and receiving printouts for all three stockpile calculations.

The previous method for making stockpile calculations was to read the coordinates, draw the end area for each slice of the stockpile, measure all the end areas with a planimeter, and compute the total volume with a desk calculator. The time required for each of the three runs described above would have been about 12 hours, so that the three together would have required nearly a man-week of time — 10 times as long as the method using the digitizing unit and computer. Although the largest proportion of the cost of a stockpile inventory is in airplane time (even though there are only two exposures), automation of the calculation procedure has significantly reduced the total cost of this service.

Considerable time is saved in reading the coordinates by providing the stereoplotter operator with contrast-controlled diapositive plates exposed on the Mark IV Electronic Contact Printer. It is easier for the operator to locate the surface of the stockpile at a given Z-dimension in an automatically dodged image (top in Figure 5) than in an image that is either too dark (such as with coal) or too light (such as with gravel or sand) as in the undodged print of the same negative at the bottom. With variable dodging, the Photo Lab normally uses a high degree of dodging for gravel or sand and somewhat less dodging for coal. It is usually worthwhile to run a test print with an estimated degree of dodging to be sure of getting the optimum photographic detail for the stereoplotter.

In our experience, it is possible to obtain the same degree of accuracy in volumetric calculations without a contrast-controlled stereo pair but it takes substantially longer to locate the coordinates. Before using the electronic contact printers, it was often necessary to print two sets of positives for each stockpile, one for the dark areas and one for the light areas in the image. For an aerial view in which the quality of detail was not apparent until it was examined in the stereoplotter, it was then necessary to make the stereo plates over again.

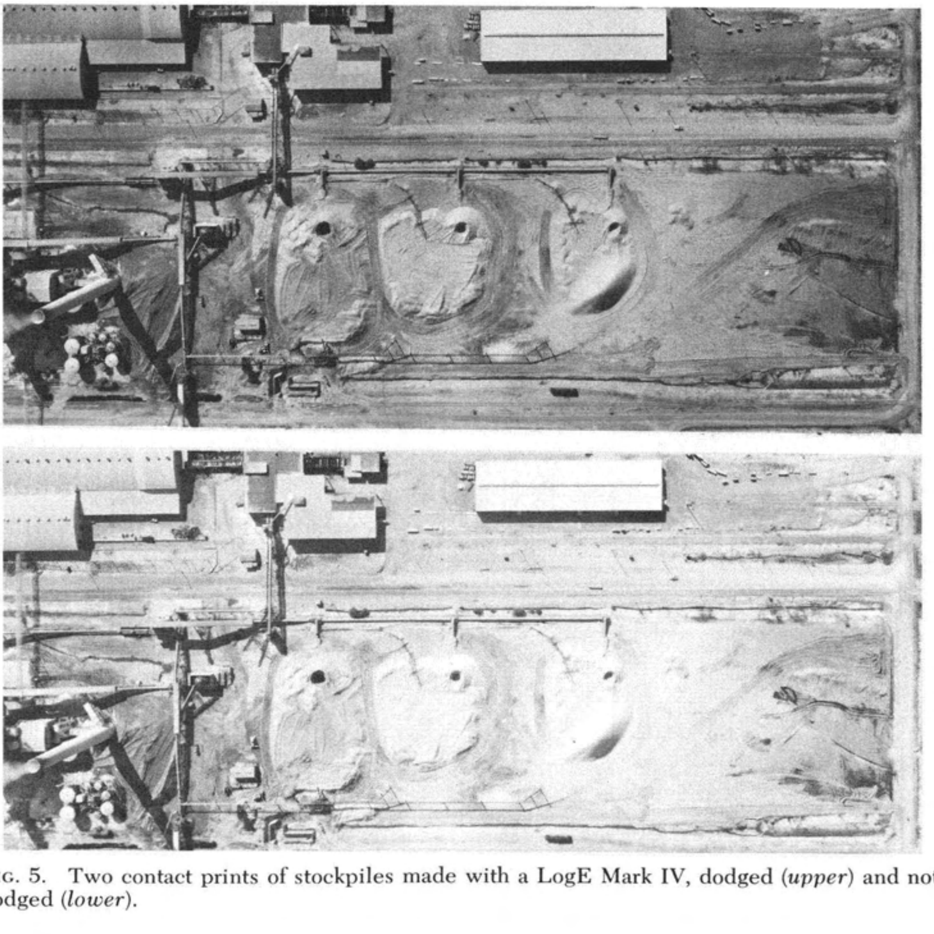

FIG. 5. Two contact prints of stockpiles made with a LogE Mark IV, dodged (*upper*) and not dodged (*lower*).

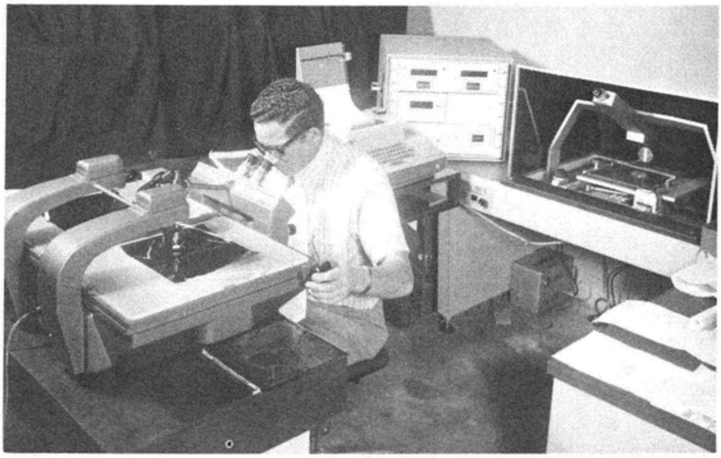

FIG. 6. Wild PUG point transfer device, MK2 Kern monocomparator, Z-axis digitizer and Teletype with acoustic-coupler for computer connection.

ANALYTICAL AEROTRIANGULATION

Another major area in which automated photographic printing and data handling equipment have increased the productivity is in analytical aerotriangulation. Because aerotriangulation can reduce the cost of ground control as much as 75 per cent, investment in the equipment shown in Figure 6 can pay for itself quite rapidly. In Figure 6, the operator at the Wild *PUG* (at left) is pugging film-positive plates for aerotriangulation used in analytical bridging. The Kern MK2 Monocomparator (at right) is used to measure the distance between the *PUG* points that have been established (there are at least three and as many as eight points on each plate). As with the stereoplotter in Figure 4, the monocomparator output is automatically digitized, punched tape prepared and entered into the Teletype terminal for transmission to the remote computer.