the edges should be completely isolated from intermediate tones and rendered as clear lines against an opaque background. Figure 6 illustrates the transition from a simple density difference to total edge isolation.

PROCEDURE

The emulsion for this transformation must have extremely high density and contrast capabilities and must be coated on a stable base. In the first step, a positive transparency is made on high-contrast orthochromatic film from the original negative, with maximum quenching and developed in a moderately contrasty developer, such as Kodak D-19. The dark lines along the image borders, as described above, will have a density higher than that of the surrounding background. The clear lines adjacent to them allow additional passage of infrared on the succeeding step and thus further accentuate the dark lines, which are then printed in negative form.

The final negative is printed in the same way as the positive transparency. After the initial exposure, however, the exposed negative remains in the printer for a short time to allow the afterglow of the phosphor screen to expose the film in the background areas. The extent of edge isolation depends on the characteristics of the developer used for this negative. For complete isolation or total elimination of tone, the film is processed in a caustic developer, such as Kodalith. The background becomes opaque, and only clear lines are left to represent the original image edges.

The accompanying slides demonstrate the type of line which can be expected. They are, of course, greatly magnified and show some degradation (Figures 7, 8, 9, 10).

The edge-isolation process offers some attractive possibilities for saving time and money, especially in producing special-purpose maps for which standard cartographic symbolization is not necessary. Currently, all mapworthy features must be represented by graphically constructed symbols, manually located. The photographic processing of image symbols by edge isolation provides a semiautomatic method of representing prominent terrain features and in many respects, the symbolization is superior. When made from orthophotographs, the imagery is accurately positioned and the resulting product is a very useful planimetric map. In addition, edge-represented maps do not require halftone screening for reproduction by lithography. Patterns valuable to geologists and others interested in the general configuration of the terrain are often more easily detected in edge-isolated prints than in the original photograph.

The relative simplicity of processing edge-isolated prints could result in their widespread use. It is, however, impossible to predict at this time all the benefits which may result from this process.

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*AP/1—A New Concept in Stereoplotting**

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IN PREPARING this paper the original intention was to briefly review the principles of the Analytical Stereoplotter and then to give some detailed information on its design and construction. And finally to discuss briefly the uses to which the instrument could be put. I found, however, that during the past year or two in which we have been developing the prototype this information has already been made available in several papers. Mr. Helava, the inventor of the instrument itself, has presented some excellent material on the principles as well as the contemplated use of such instrument and now I notice in a recent issue of "PHOTOGRAMMETRIC ENGINEERING," that Dr. Johnson of the Bendix Research Laboratories Division has presented a very thorough discussion of the basic concepts involved in the prototype instrument.

Also I must confess that I myself have been

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guilty of describing the instrument in public at the last International Congress in London.

But there is one matter that none of us have been able to do until now, and that is to show photographs of the completed prototype instrument and to discuss it with you.

The first prototype model of the AP/1 actually is destined for delivery to the Fairchild Camera & Instrument Corporation and ultimately to the U. S. Air Force. The instrument is now in Detroit where it is being checked at the Bendix Research Laboratories. The reason for this is not surprising inasmuch as the stereoplotter itself was designed and fabricated at OMI in Rome, Italy and the electronic computer, which is an integral part of the plotter, was designed and built at the Bendix Research Laboratories. It was decided by the collaborating companies that the logical place for integrating the components and checking them out would be at the Bendix Laboratories.

The AP/1 complex consists of three basic independent consoles, that is, independent in material construction rather than function. These independent units are the stereoplotter itself, the *XY* coordinatograph plotting unit and the electronic computer. Of the three units the one which is most conventional in appearance and which is readily recognizable is the coordinatograph. This device is similar in major characteristics to all other coordinatographs in use with today's first-order analogue stereoplotting equipment. Its function is to draw out in analogue fashion, on a two-dimensional reference plane, the position of the floating mark which the instrument operator sees in his three-dimensional stereomodel. The device is provided with drawing heads, scribing heads and, also, a microscope for observation of plotted positions. Actually, except for some minor innovations, it is quite conventional. Such minor innovations are standard practice of OMI in utilizing synchro motors to reproduce commands from the stereoplotter to the coordinatograph, and also for the first time, at least in our practice, to utilize an *H* configuration of lead screws instead of the more customary *T* configuration. The *H* configuration provides a more positive drive and insures a greater accuracy provided that the two parallel lead screws required to move the primary carriage are properly synchronized. This requirement is taken care of very nicely by means of small slave synchros which, if they go out of phase with respect to each other and thereby threaten the accuracy of the *XY* plotter, start off an acoustic and visual alarm system which is both effective and unnerving.

I do not pretend to be an authority on the computer. In conversations with the group at Bendix who designed and built this computer I absorbed a certain amount of general information as well as an impressive vocabulary which might overwhelm an old-line photogrammetrist but will make no impression on any electronic engineer or, for that matter, any of our newer group of photogrammetrists who spend more time chasing electrons than parallaxes. The first thing one notices about the computer is that it is blue. The second is that it is quite independent of the stereoplotter itself, physically. I hope this is not misleading inasmuch as the relation between the computer and the stereoplotter is every bit as dependent as the human brain is to the human muscles.

This particular computer bears no resemblance to any standard commercial computer in a sense that it is a modification of any existing concepts commercially available. Construction by Bendix does not imply that it is similar to either the Bendix G15 or G20. It was specially designed by the Bendix Research Laboratories Division to do the task as outlined by Mr. Helava and the photogrammetrists of OMI. Dr. Johnson, in his paper in the September 1961 issue of "PHOTOGRAMMETRIC ENGINEERING," goes into considerable detail and, in a very readable fashion, as to the characteristics of this computer. I need only say, as far as the general characteristics of the computer are concerned, that it is a combined digital differential analyzer and whole number computer. Only in this way

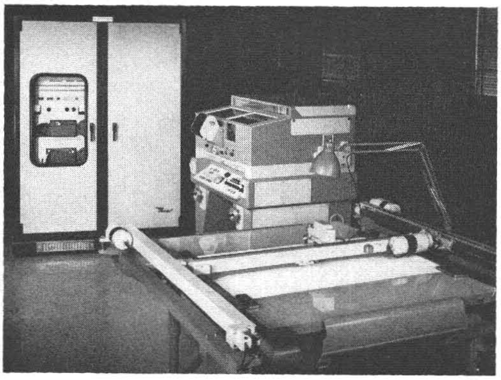

FIG. 1. The AP/1 system.

was it felt that the computer could perform the very high-speed calculations which would be necessary during plotting operations, and at the same time be capable of handling the complex programming and equations called for by the photogrammetric parameters which the computer must handle. The operation of the computer is simplified as far as possible so that the photogrammetric instrument operator does not require any degree of specialized computer knowledge. He should be able to turn the computer on and off and also to feed to the computer memory, standard punched paper tapes upon which any precomputed or known data which are desired for entry into the computer memory as well as the programming for the activity required. The computer also permits the tape punching or output of discrete data information at the control of the operator. These data can be visually displayed if desired by means of a flexowriter or similar type equipment.

In addition to furnishing the computer with known values by means of a tape reader, the operator can also send to the computer specific information by means of numerical decade switches located on his control panel, which is on the stereoplotting instrument itself.

For next consideration is the stereoplotter console. The appearance of this unit differs somewhat from the more conventional picture of a first-order steroplotting instrument. Actually inasmuch as the computer handles all space geometry problems in a digital fashion—in the analogue instruments these must be handled mechanically or optically—this particular instrument has been able to be compacted to a greater degree. It is also much more simple in design than the analogue instrument of the same class. No function is required of the binocular optical system other than to present an image of each photographic plate with the highest resolution and also at the same time fuse the floating mark with this imagery. No performance is required of the mechanical system other than to displace the photographic diapositive plates with respect to the optics in the XY plane. There is no requirement or capability for tipping or tilting these plates with respect to the instrument axes or maintaining any precise spatial orientation. These freedoms, of course, allow the optical and kinematic design of the instrument to reach a very high state of performance perfection and, naturally, very favorably affecting the obtainable accuracy.

Actually the operator has at his command all the controls and even more than he would normally find on the first-order universal analogue stereoplotter. He is free to introduce to either or both diapositive plates any specific amount of tip or tilt or Kappa or, if he prefers, to do it on a trial-and-error basis as he would conventionally. Only instead of reaching for mechanical gearing controls or electrical rheostats, which directly affect the position of the plate in its orientation, the operator of the AP/1 depresses an illuminated

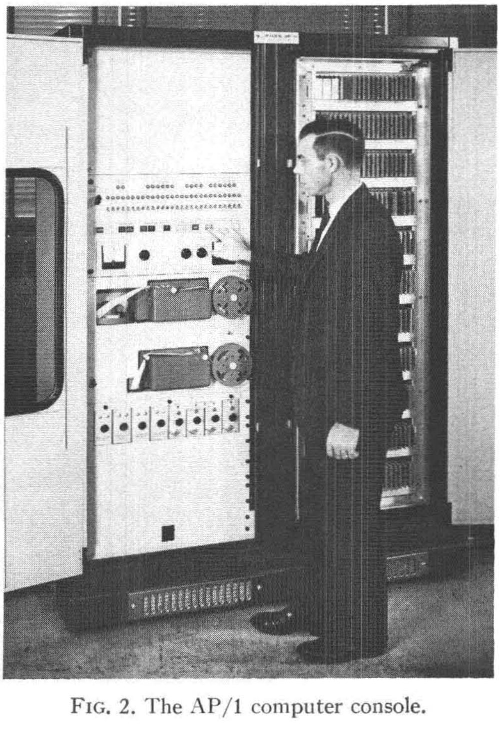

FIG. 2. The AP/1 computer console.

switch button which addresses certain quantitative orders directly to the computer memory. The computer reacts instantaneously to this information and controls the necessary driving devices which will move the diapositive plate in the XY plane by the theoretical amount required for the position which is being observed.

Very briefly the sequence of operations for a stereoplotter operator is analogous to the same operations which he would perform on a conventional instrument, but in this case such operations will be more automatic, faster, more accurate and, we hope, less susceptible to random errors. This latter comment should be of significant importance during the process of aerial triangulation.

In actual operation if the parameters of the stereomodel are already established as a result of analytical triangulation or are known constants, the operator's task for orientation is relatively simple. These data are entered into the computer by punched tape and it is only necessary for the operator to place his plates in the instrument and perform the necessary interior orientation. This interior orientation consists of reading the four fiducial marks of each plate and computing the center of gravity. This center of gravity, corrected for displacement of the center of symmetry or the principal-point, establishes the origin of the photo-coordinates. Presumably then if all the data entered into the computer memory are correct, the operator has a fully established absolutely oriented stereomodel. Should these data be not quite that accurate it would be necessary for the operator to read six points in the stereomodel for Y parallax readings. These readings would be automatically addressed to the computer and the computer would then solve a least squares solution for the relative orientation. Absolute orientation is performed by the operator by comparing the known coordinates of specific points in the stereomodel, which are already in the computer memory, with observed points in the stereomodel. When the discrepancy between the readings for the same points is zero, or below acceptable error, then the absolute orientation is completed. After this step the operator, if he desires, can completely record all the parameters of his absolutely oriented space model on punched paper tape for future reference.

The actual drawing out of charts, maps or profiles is accomplished in a conventional way with handwheels, or can be done with the OMI patented steering wheel device. Also, of course, at any time desired, specific digital data on any point can be recorded on the punched tape at the command of the operator.

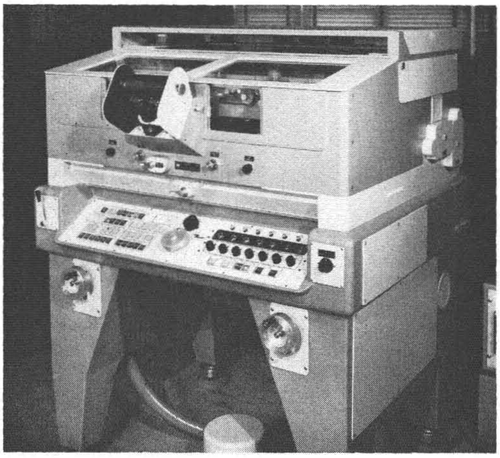

FIG. 3. The AP/1 stereoplotter console.

The AP/1 has another noteworthy capability to which very little attention was paid during the design of the instrument. It now appears to be quite important in its applications to civil engineering projects which require profiling and earth work computations. Due to the versatility of the computer and the use of the steering wheel, it is feasible to rotate the instrument or the model axes at will, so as to line them up directly with any profile or crosscut. This allows the operator to move directly in the stereomodel according to any arbitrary axes he desires. This, in turn, enables him to make precise profiling and cross-sections in any direction in a very simple manner and with great precision while at the same time drawing these profiles out on his coordinatograph with any reasonable ratio of height to length scales. He can almost simultaneously utilize the computer capability to compute areas as they are being drawn off. The computer also has a definite capability of being utilized independently of the stereoplotter at such times when stereoplotting may not be required. It is hoped that highway design people will find this instrument, or certainly these capabilities, of great interest.

Actually we are almost embarrassed at this time to admit that none of us who have worked on the design of the instrument, and I believe I can include Mr. Helava, the inventor, are fully aware of all the potential of this system. There are capabilities buried within it which we had not even anticipated and which are a continuous source of surprise and pleasure to us. It is an exciting development and we are quite excited about it.