*Automatic Point Identification Marking and Measuring Instrument**

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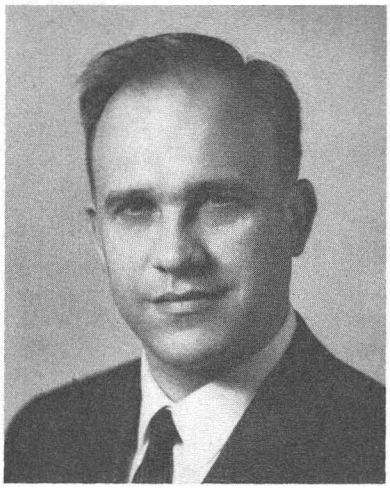
AS THE name implies, the Automatic Point Identification, Marking and Measuring Instrument is an integrated system for the selection, identification, marking and measurement of pass-points and control-points. It is intended primarily for use in control extension by analytical triangulation. The typical problem in selecting pass-points is as follows:



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PROBLEM

Figure 1 contains a highly idealized representation of the area location of pass-points on a photograph and their location on overlapping and sidelapping photographs. The problem is to rapidly locate pass-points on the center photograph within the tinted areas numbered 1 through 9 that also appear legibly on the overlapping photographs.

Conventional selection techniques are tedious and restricted to the selection of points which stand out as readily identifiable to the human eye. The process requires a highly skilled technician and is very time-consuming. Often there are no readily identifiable points and compromises must be made which result in a lowering of the accuracy with which points are located. Often points must be selected in locations of sharp changes in relief; this condition makes recognition of the point difficult as its appearance in different photographs is radically different because of the change in perspective. The selected point is sometimes a bush or some other vague, easily misidentified object. Often points must be omitted altogether and the net result is a weakening of the control extensions. To compound the problem this time-consuming, scrutinizing operation involving the identification of a pass-point is repeated over and over again by different individuals performing various tasks before compilation of the area is complete.

In test areas for research work, highly idealized pass-points or control points are established by placing clearly definable panel markers in open flat areas such as shown in Figure 2. This type point is readily identified in all photos and can be located and measured with extreme accuracy. This can be done at high speed and with practically no risk of misidentification. The Automatic Point Identification, Marking and Measuring Instrument simulates the panel marker by simultaneously marking the conjugate images on all overlapping photos, with an identical mark. This operation retains all the desirable features of the panel-point plus the fact that the photo-coordinates are measured at the same time.

SYSTEM DESCRIPTION

The optimum complete system (Figure 3) for covering the triple overlap and sidelap consists of three precise air-bearing type $X-Y$ comparators; three unprecise $X-Y$ comparators; six cathode ray tube scanning-correlator servo systems for driving the comparators; six marking systems for marking the conjugate photo-images being scanned; and a control console containing a stereo and mono monitor viewing screen and a reference scanner. The measuring system is optionally either a Ferranti photo-electric diffraction measuring system or the Link Fringecount interferometric measuring system with type-

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writer-paper tape read out. As shown in Figure 3, the experimental instrument presently being constructed to prove out the minimum system concept contains only two precise air bearing type comparators and a reference scanner.

PRINCIPLES OF OPERATION

The principles of operation are based upon the techniques of scanning and correlation of photo-images developed at Fort Belvoir during research in automatic map compilation. The basis of operation is the ability to slave the comparators such that the images being observed and subsequently measured are always conjugate images of the image under the measuring reticle of the manually controlled comparator. This comparator is called the "master"; the comparators that are servo controlled to the same image are called the "slave" comparators. The operator optionally, at any time, may select any *one* of three precise comparators to be the manually directed "master" comparator. For use with control-point photos, the operator may optionally select the fixed reference scanner containing the control-point photo, to be the "master" image. The three unprecise comparators are for precise marking of conjugate images on sidelapping strips only. They have no measuring capability.

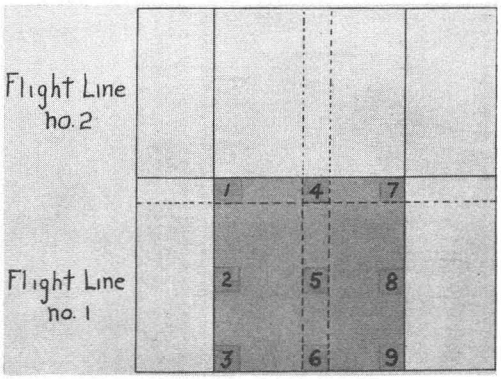

FIG. 1. Pass points.

OPERATING SEQUENCE

The normal sequence of operation is to select, mark and measure pass-points and control-points on Flight Line No. 1 (Figure 4), with the precise measuring comparators and to simultaneously mark conjugate images as they appear in the sidelap area on Flight Line No. 2. After completion of Flight Line No. 1, Flight Line No. 2 is placed on the precise measuring comparator and Flight Line No. 3 is placed on the unprecise comparator and marked in its sidelap area. This operation is repeated until all the flight lines are marked and measured.

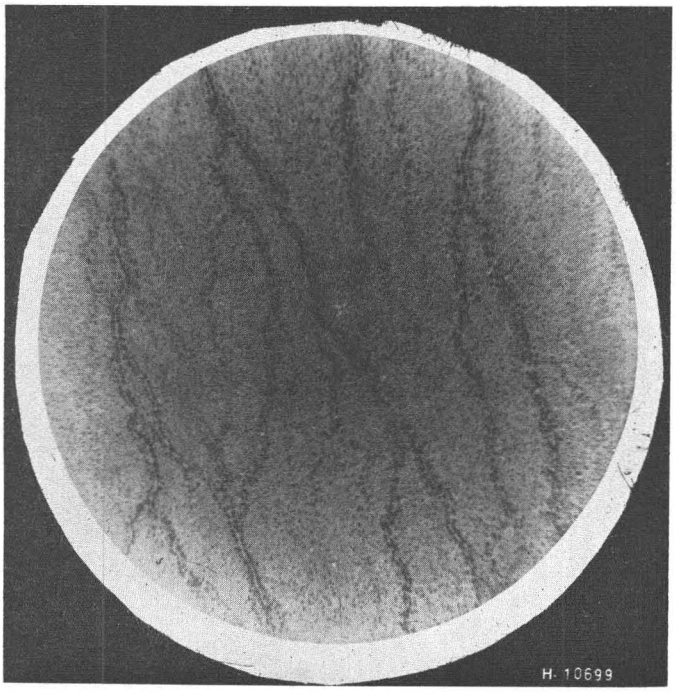

FIG. 2. Panel point.

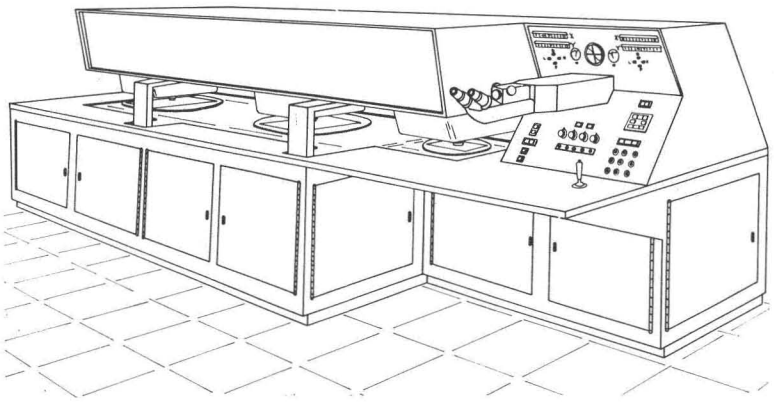

FIG. 3. Automatic point identification marking and measuring instrument.

It is obvious that when there is only a single flight line the unprecise marking comparators are not required. It also should be apparent that ideally three precise measuring and marking comparators are needed to observe the triple overlap for simultaneous selection of an acceptable pass-point in this area. However, in practice it may be that only two comparators will be necessary. An acceptable pass-point is one in which the conjugate image as it appears in all photos is sufficiently clear and defined to permit the image correlators to function properly. When the correlators are functioning properly the conjugate images are correctly positioned for marking and measurement.

It should also be pointed out that the measurements of the pass-points on each diapositive plate must be completed before moving the plate. The sequence of plate placement and removal is similar to that used with a conventional three-plate comparator such as the Nistri TA-3. That is, after completing the selection of points on diapositive No. 1, diapositive No. 4 replaces No. 1. After completion of No. 2, No. 5 replaces No. 2, etc.

OPERATION

Figure 5 is a basic representation of the operator's control console. A simplified typical step-by-step operation sequence is as follows: the operator would initially have available a complete set of contact prints on which the general areas where pass points are desired are marked as well as the general areas of the control-points. He would also have a set of small 2-×2-inch control-photo-plates or film chip with the control point location accurately marked. There is one plate for each control-point. The present plate being experimentally used for this purpose is the standard multiplex diapositive plate.

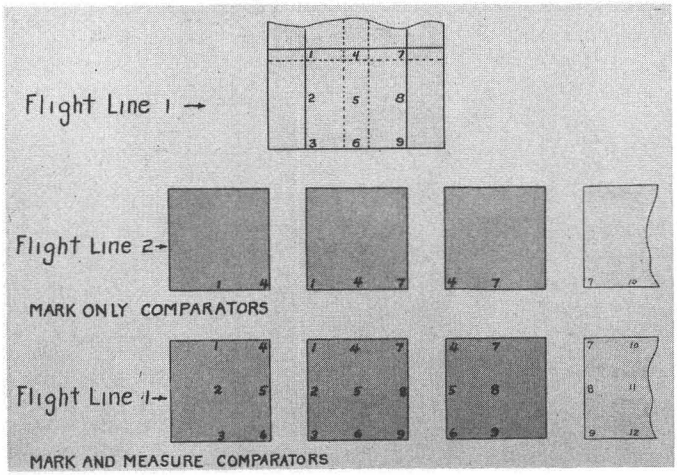

FIG. 4. Comparator arrangement.

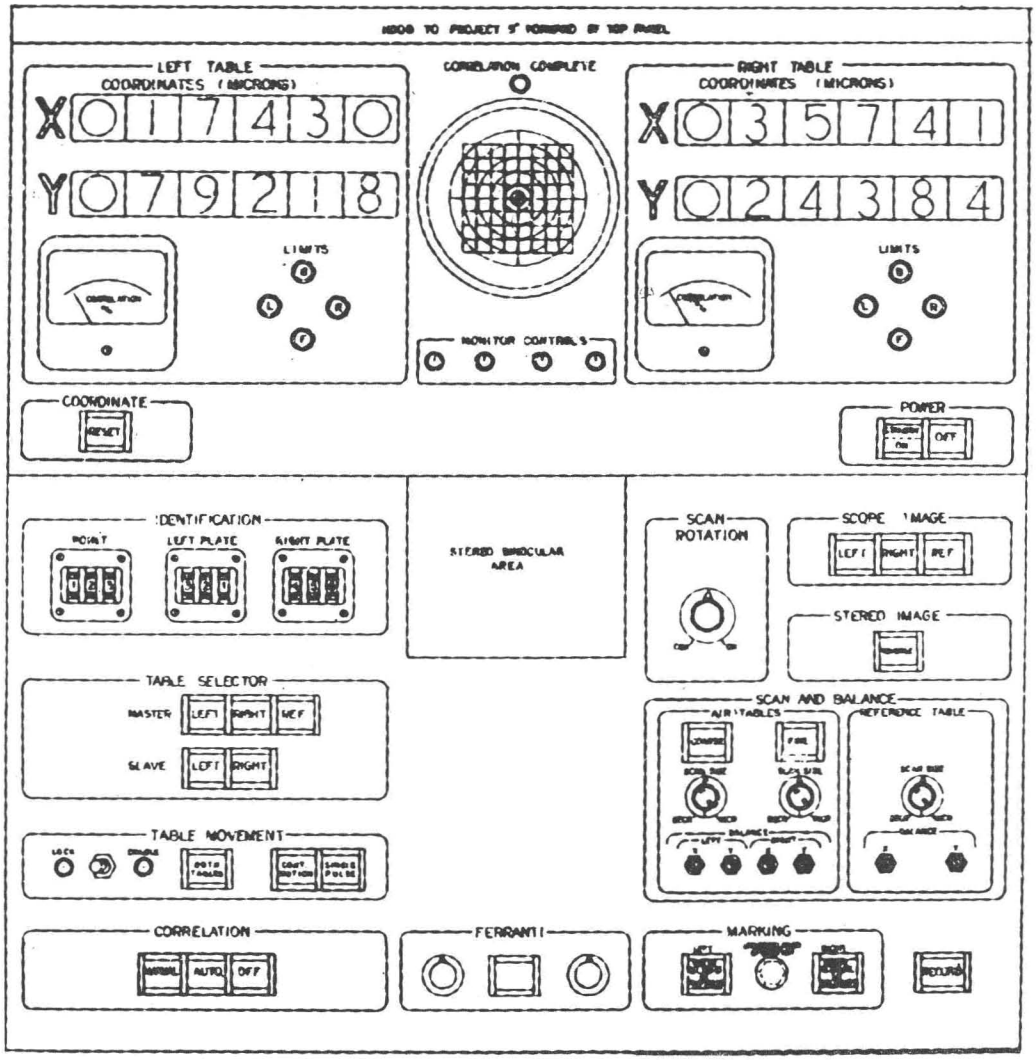

FIG. 5. Control console.

The operator's initial step would be to place the diapositives in their respective comparator plate holders and to secure them without any special effort to precisely line up the photo fiducial marks with the measuring system axis. Then using the controls on the console and observance of the imagery on the monitor screen or stereo viewing screen, he would manually bring each photo in turn into position so as to view a common area. The area selected would be reasonably level. He would then manually, using the dove prism controls on the console, rotate each comparator's image to remove the effects of large amounts of crab.

He is now ready to select, mark and measure pass-points. Depressing the automatic button causes the comparators to slave to the manually controlled comparator which is selected by the "master" selector switch. Viewing the monitor screen or the stereo view screen, the operator directs the measuring reticle of the master comparator to the first pass-point area. The slave units simultaneously move to the conjugate areas on their respective photos. A panel of lights glowing green informs him the area on each comparator is correlating satisfactorily. He then depresses a "fine" scan button which reduces the size of the area being scanned and results in the positioning of the conjugate images to a higher order of accuracy. The

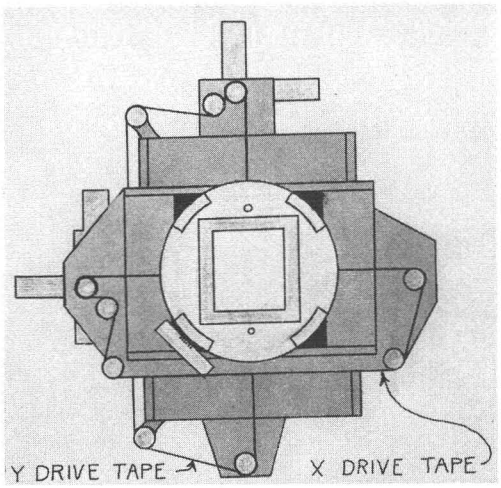

FIG. 6A. Comparator.

lights should remain green; however, if a light is red the master is moved slightly until a point is located that is satisfactory as indicated by the green lights. He then sets the identification number for the pass-point and depresses the record button automatically recording the location of the point as it falls on each comparator and the mark button which automatically marks the location on each diapositive. The operator then proceeds to the other pass-points and the fiducial marks in turn, measuring and marking their locations. To mark and measure the location of a control-point, a library diapositive containing the marked location of the control-point is placed in the reference scanner and is centered to the index mark on the monitor screen. This index mark is the common reference for all the comparator measuring systems. The pass-point area is then manually brought into view on the measuring comparators, and the control-point image is rotated and adjusted to scale on the reference scanner. The measuring comparators are then switched to slave to the reference photo-image. When positioned satisfactorily the measure and mark buttons are depressed recording the locations of the control-points simultaneously on all diapositives.

TECHNICAL HIGHLIGHTS

COMPARATORS

As shown in Figure 6A and 6B the comparators employed use air-floated tables of a unique design. They are for practical purposes, friction-free.

As shown in Figure 7 five-inch cathode ray tubes are employed for scanning the diapositives. The scan size is continuously variable from 80 microns to 800 microns in the fine-scan position, and from 800 to 8,000 microns in the coarse-scan position. This gives a continuous range from 0.08 millimeter to 8 millimeters. In the fine-scan position

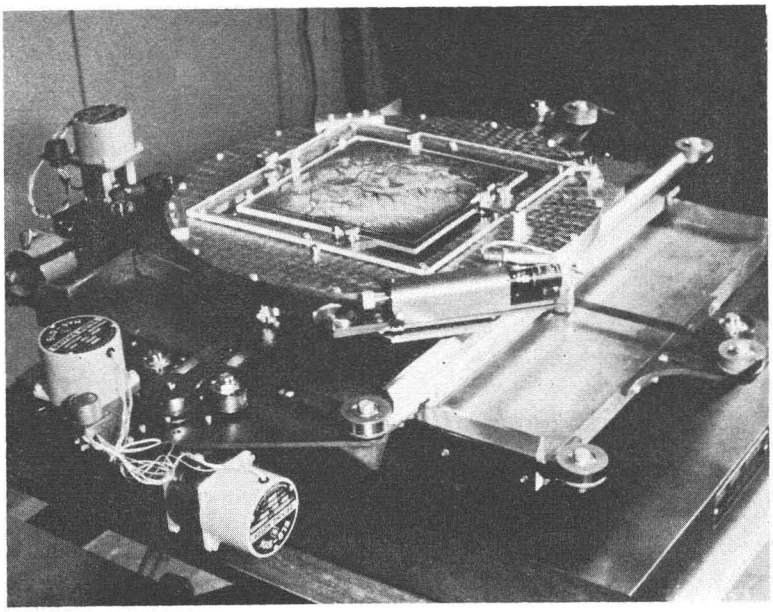

FIG. 6B. Comparator.

there is a 100 times reduction of the scan as it appears on the face of the cathode ray tube; in the coarse scan position there is a 10 times reduction.

MARKING SYSTEM

The marking system consists of a small heated die that burns a mark in the diapositive emulsion. The dies are interchangeable. Experimentally several sizes and marking patterns will be tested. A satisfactory mark is being produced as shown in Figure 8. Temperature and pressure are non-critical. Temperatures from 300 to 500 degrees Fahrenheit at pressures from 1 to 16 ounces produce acceptable marks. The dies presently being used produce a 50 micron dot with a 2 millimeter circle of 50 micron thickness. Dies of smaller sizes and different outside circle sizes and widths are being fabricated. The die which is most suitable for a particular job will be selected by experimentation.

ACCURACY

The accuracy of entire system including marking is expected to have a standard deviation error of less than 4 microns and a maximum error of less than 10 microns.

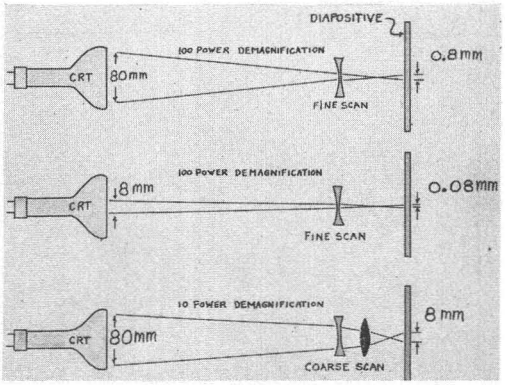

FIG. 7. Photo scan system.

STATE OF DEVELOPMENT

A contract was awarded to Link Division of General Precision to build an experimental two-comparator version of the system. The contract was awarded in March 1961 and delivery is scheduled for March 1962.

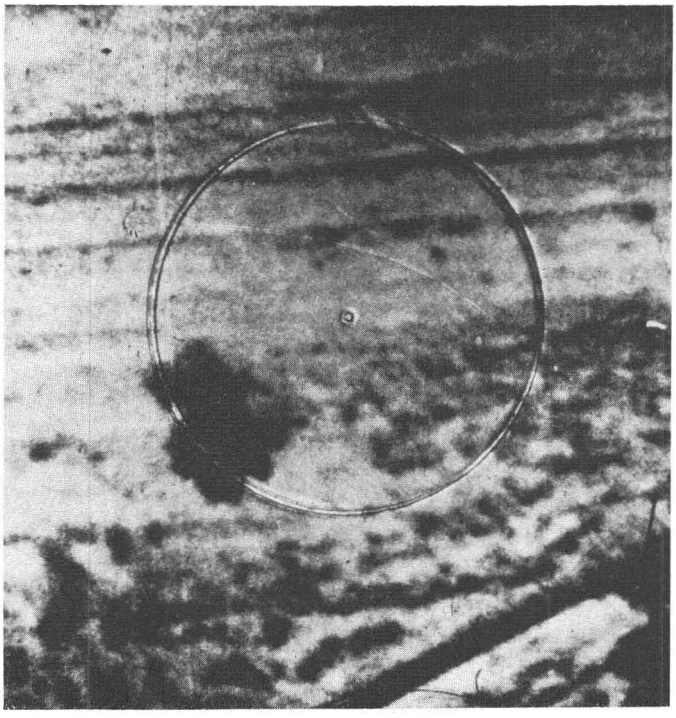

FIG. 8. Marking system.