GEOLOGICAL SURVEY

Application of the Radial Intersector in the Topographic Branch

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THE mapping problems to which the Floore Radial Intersector is applied in the Topographic Branch of the Geological Survey are greatly different from those in the Alaskan Branch. The Topographic Branch is engaged primarily in making a complete series of maps in quadrangle form at scales from 1:24,000 to 1:62,500, and these quadrangle maps, if reasonably possible, should meet grade A standards of accuracy. This requires a considerable amount of third-order horizontal control. Consequently, it is the usual practice when the control consists of transit traverse to have one line of control located near the perimeter and one line across the center of each quadrangle, although considerable variation from this ideal must often be tolerated because of the lack of roads or other suitable routes for traverse. In the less frequent cases in which the horizontal control consists of triangulation, a smaller number of points are available, but as these are distributed over the whole quadrangle, the final results will not be greatly different.

In the Topographic Branch, therefore, the Radial Intersector system is used chiefly in working up quadrangle units for which a line of control will be available near the perimeter of the sheet and another line across the center. Usually the unit is a 15-minute quadrangle, embracing an area about 13 miles wide by 17 miles long, a total of about 220 square miles. When 7″×9″ photographs on a scale of about 1:20,000 are used, as is often the case, about 7 north-south flights are required, with a total of about 140 prints. The compilation is made on the approximate scale of the photographs. The published maps should have a horizontal accuracy for most points of 0.02″, and since the publication scale for 15-minute sheets is usually 1:62,500, the desired tolerance for the radial intersector control on the 1:20,000 scale is about 0.04″ to 0.06″, or about 1/20 of an inch.

The detail is adjusted to the intersected base by tracing directly from the photographs by the use of an overhead projector or with a Lucidagraph. Though it is entirely possible to compile the maps on drawing paper, topographic acetate sheets are still used as the base because of the convenience in checking and tracing small detail directly from the photographs.

Although the Floore Radial Intersector method is similar in operation to the slotted template method, there are a number of differences which should be mentioned. With the slotted template method, if a control point is plotted in error, if it is omitted, or if a stud is not centered over it, the error is difficult to detect without taking up the templates. With the Radial Intersector method, in which the control sheet is accessible, such errors can usually be detected and corrected with little difficulty. One of the chief difficulties of the radial control man is that due to slight errors in plotting, in identifying control, or in the geodetic control itself, adjacent plotted control points may not agree closely enough with the corresponding intersected positions to avoid strains in the system, and small errors may be made by holding to a control point which should be disregarded. Large errors are readily apparent, but small ones that are close to the Survey's limit of tolerance for horizontal accuracy can easily be overlooked.

In the Geological Survey method each control point is carefully inked with its usual symbol and, in addition, with a blue circle the diameter of the stud pinned to it. Before the stud is pinned in position the intersector units in that area are connected in position, and if any of the plotted and intersected points are in disagreement, the error can be detected by the failure of the studs to be superimposed over the control circles without strain, in which case further checking should be done. A similar advantage in detecting such disagreements could be gained with the slotted template system by using lucite studs, over the control points, which would make their agreement or lack of agreement with the control points below apparent.

Less strain in the units and slightly better radial control adjustments might result if the layout were fixed in position by pins through the centers of the units adjacent to the control rather than through the studs over the control points. Such a system would require that the agreement between plotted and intersected control positions be visible.

Interference between arms and units is something of a problem with both the slotted template and the Floore Radial Intersector system. In the former system the templates are trimmed to a size as small as possible, and in the latter the units should be made up of metal arms no longer than necessary to reduce the interference. In both systems judgment must be used in the selection of intersection points to obtain their proper distribution, otherwise interference will result. The Floore system has an advantage in that any such interference will be visible without removing any of the units.

As no slot cutter is required for the Floore system and all arms and parts can be used over and over again, the cost of material is less than for the slotted template system, and the equipment is more portable, a special advantage for military operations.

A less emphasized point of difference between the two systems is that in the slotted template system a tolerance must be allowed for differences between the width of the slots and the diameter of the studs. If the tolerance allowed is too small, strain and deformation of the slots will occur. In the Floore system the slots can be cut to fit the studs with a tolerance as small as machining practice will permit and the inaccuracies of the unit can be taken up by the elasticity of the arms. It may be reasoned that the adjustment of small and inevitable errors will be more satisfactorily made by elasticity rather than by play in the slots or by deformation, but only considerable research and tests will prove which is better.

The azimuth or center-to-center arms of the Geological Survey's Radial Intersector have not yet reached a completely satisfactory stage of development. Various methods have been tried, but the one most favored is to use standard arms short enough to avoid interference between centers and held in alignment with two studs through their overlapping slots. It has been found through tests that the azimuth system in a mechanical method is not so important as it is in graphical methods and that only small differences in adjustment will be found if it is omitted entirely, provided perimeter control is used. Other tests indicated that almost identical adjustments will be obtained if only one stud is used to connect the units, thus holding them laterally but not in azimuth or orientation. This is not always true, however, as in the case of a layout which lacks control along one side. If the center of a photograph cannot be accurately transferred to the adjacent photograph, as when it falls within a body of water, it is much better to omit the azimuth connection.

Preparation of Photograph

In marking conjugate centers and picking the intersection points for radial intersector control, the methods used vary slightly with the individual, but all are similar to the usual radial control methods. The principal points are transferred by stereoscope, or a definite image point is picked near the principal point and the conjugate substitute centers are located visually. If the area being mapped is of high relief or if there is evidence of considerable tilt in the photographs an approximate tilt analysis should be made.

Intersector points are chosen, where possible, so that each is common to three photographs of two overlapping flights. The system works better and with fewer interferences when the number of points used is kept to a minimum. More than six intersection points per photograph are not usually necessary or desirable. Eight or twelve intersection points per intersector unit have been used with no impairment of the resulting layout, but the additional points caused a loss of time in setting up the unit and checking against interference without adding

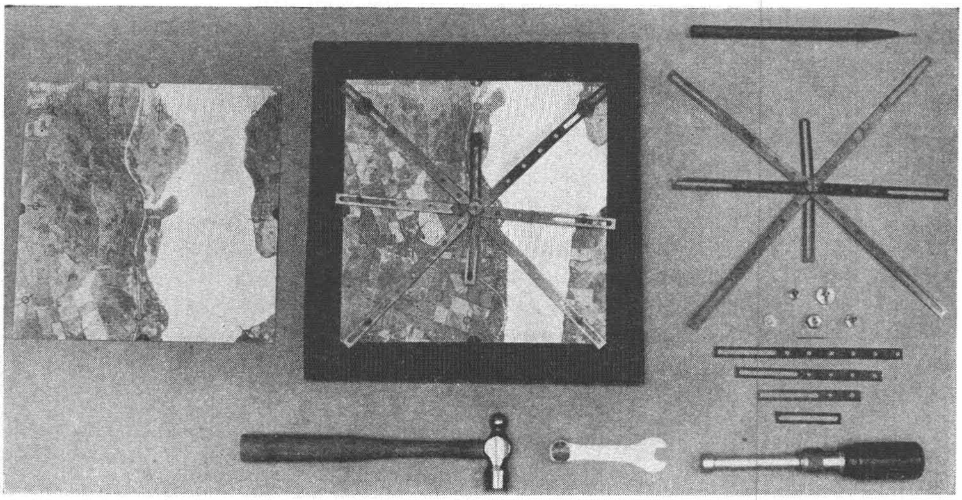


FIG. 1. Radial Intersector Parts and Unit

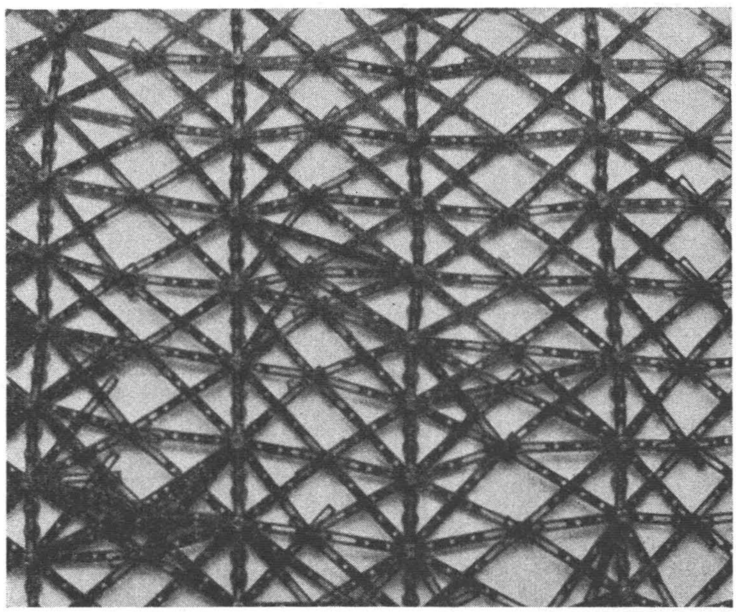
to the accuracy of the radial control. Secondary intersections are made graphically after the primary radial point system is completed. When two flights overlap so that it is not practicable to choose an intersector point that will fall on three photographs of each flight, it is usually better to use a single point that falls on three photographs of one flight and two of the other rather than to pick an additional point unless this is required for compilation detail.

Contrary to common belief, tests in which only five cuts are used for each intersection show results almost identical with those using the usual six cuts. These tests were made without a special picking of points, merely by disconnecting the sixth arm at each intersection stud in a standard layout. The Floore system lends itself especially well to such research, and some surprising results are obtained. Usually such tests are made on short notice on some regular job, and more systematic research is needed.

Control points are usually identified on the photographs in the field, prior to the radial control operation. Often the marking of these points on the photographs is not as accurate as desired, and the characteristic of the Floore system by which a stud can be released from its corresponding control point to see if it will maintain that position without undue strain permits a very valuable check.

CONSTRUCTION OF UNITS

The procedure for making up intersector units here described has been satisfactory, but many details and short cuts might be developed to increase both production and accuracy. Each photograph is first placed over a special cork-composition mounting board, and special pins are driven vertically through the principal point (or substitute principal point) and the radial control points. Pins are also driven through the azimuth rays, which should be previously marked on the photographs, at the proper distances to hold the azimuth arms. The pins are made of music wire of a diameter such that they will just fit the holes in the studs and bolts. The upper end of the shaft is left the same diameter as the original wire, but the lower end is ground to a smaller diameter so that it will make a much smaller hole when driven through a photograph or the acetate projection sheet. After a bolt has been placed over the pin at the principal point, and studs



A Section of Assembled Units.

over the other pins, the metal arms of suitable length are placed in position, as shown in Fig. 1.

With the arms in position, a washer is placed on the bolt over the arms, and a nut is applied to the bolt and tightened. A special wrench is used to hold the bolt from turning, and care must be taken in the method of tightening the nut to prevent any strain in the arms. No trouble is encountered with slipping of the arms except when inaccuracy in the building up of individual units is so great as to cause serious strains when the units are assembled.

Preparation of Projection Sheet

Because of the inconvenience of determining the average scale of photographs for each quadrangle and the computing and construction of special scale projections, a standard scale is usually adopted for a whole project. A determination of the average scale for the photographs of the project is first made and a suitable scale for the whole unit is then adopted. Thus, on one project a scale of 1:20,000 was first planned, but as the photographs varied in scale from

1:19,500 to 1:21,000, the standard was later changed to 1:20,500. A metal-mounted regional projection template has been devised from which a $7\frac{1}{2}$-minute projection can be traced for any latitude within the region. If this template is carefully constructed, projections traced on the acetate with its aid are more accurate than if they were constructed individually on the acetate in the usual manner, and there is a substantial saving in time. Projections covering larger areas can be made by tracing one $7\frac{1}{2}$-minute unit at a time.

Plotting Control

The horizontal control, which is usually in geodetic coordinates, is plotted on the acetate sheet by the usual diagonal scale method. The permanent control points are marked with a small triangle, and the intermediate control points are marked with a 0.2″ circle. In addition to these symbols a blue circle with the same diameter as that of the studs is centered on each control point.

Assembling of Units

The projection acetate sheet is usually placed on a large composition-covered table. The units are then assembled on the sheet and held in position by the special pins. Studs are pinned first to the control points that are judged to be the more accurately identified on the photographs. The intersector units are then connected in proper position with respect to the control, beginning with the flight which is best controlled. After the units for several flights have been assembled, a check is made to see that the intersected control positions agree with the plotted control positions. If the stud representing an intersected position can be superimposed over the corresponding plotted position with little strain it is pinned exactly to the plotted position. If an appreciable difference in position exists an investigation is made. The error is located and corrected if possible, otherwise that control point is disregarded.

After the units have been assembled and pinned to the accepted control points the arms are tapped and the studs rotated to reduce or eliminate strain and to assist the assembly in reaching its best adjustment, after which pins are driven through a few of the studs to prevent any movement from that position. The adjusted positions are transferred to the acetate projection sheet by means of a fine-pointed plotting needle which will just fit the holes in the studs and center bolts, through which it is forced with enough pressure to pierce the acetate. The intersector units are then removed, the radial control points circled, and the principal points numbered. Any intermediate or secondary radial control points that are required are intersected graphically.

Compilation of Detail

The compilation of detail is similar to that of most planimetric radial compilations. Usually the photographs are inspected in the field prior to the radial control work, at which time all detail to be compiled is inked on alternate photographs with colored ink. The use of overhead projectors has frequently been explained. The Lucidagraph has the advantage that it can be adjusted for tilt without detectable loss in focus; though primarily a field instrument, it is well adapted also for office use.

The detail is inked on the acetate sheets with craftint celluloid ink. No attempt is made to obtain a finished appearance, as it must be reinked after it has been photographed. The effort is made, however, to compile the detail with sufficient accuracy so that the published map will qualify under grade "A" standards of accuracy.