MANUAL OF PHOTOGRAMMETRY AND TOPOGRAPHICAL DRAUGHTING
SLOTTED TEMPLATES

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SLOTTED TEMPLATES
INSTRUCTION FOR THE USE OF SLOTTED TEMPLATE EQUIPMENT

GENERAL DESCRIPTION

The slotted template method of compilation from aerial photographs is an extension of the basic radial line plot of principal points and minor control points. It permits the combination of several runs of photos to be fitted to ground control at a desired scale by the substitution of a template of some suitable medium to represent each photo in the assembly. Each template has a circular hole punched to represent the principal point, and slots cut radially from the centre hole to represent the radial lines of the minor control plot. The templates are assembled in the form of a mosaic held together by hollow cylindrical studs which represent the intersection of radial lines through common points of detail in the photo over-laps. The studs have a wide base of approximately half an inch in diameter to provide stability in the assembly, and the outside diameter of the spindle is in such relation to the width of the slots and the diameter of the principal point holes that the fit is snug without binding.

In a single strip the templates are assembled with a stud passing through the principal point of each template and also through the principal point base slots of the adjacent templates. A stud representing each minor control point passes through the radial slots relevant to that point, which occur on three consecutive templates. Assembled in this way, the strip of templates may be extended or compressed in length, with the studs moving outwards in the slots as the strip extends. If coordinates of ground control points are available such a strip may be fixed in its correct position on the grid. If a stud representing a ground control point is fixed in its plotted position on the grid and slots to that photo point on the templates placed over it, the strip of templates can be swung around this fixed point and pulled inward or outward radially from it. The strip can therefore be moved so that slots to a second fixed point can be dropped over a stud representing the grid position of that point, and thus the strip of templates between the two control points can be fixed in position in relation to the grid.

Adjacent strips are similarly assembled and fitted over studs representing common lateral join points previously intersected in the first. By using ground control points on these adjacent strips it is possible, in this way, to build up whole areas to a common scale on a grid table. There is virtually no limit to the size of the assembly it is possible to put down by this method. The limiting factor is the size of the available surface which is suitable for the preparation of the grid board.

PRELIMINARY WORK

The flight diagram is checked thoroughly by carefully laying all the photos down in the form of a loose mosaic. Any tie runs will be similarly treated. At this stage it is advisable to plan the system of lateral joins between runs. If special join points are required in addition to minor control points, this will be readily seen and particulars of photos requiring special treatment should be written down for future reference.

The approximate scale of the photos is worked out and a suitable compilation scale selected. It should be borne in mind that the method permits of assembly of the templates at a scale considerably different from that of the photographs, but that the inconvenience of compilation at a scale differing from that of the photos still exists. The plotting should therefore be at a round scale conveniently close to that of the photos in the area of greatest detail. The assembly board is then gridded to the selected scale.

All existing ground control is marked on the flight diagram and the control points are identified on all photos on which they occur. This step should be verified by an independent check by a senior member of the section.

From the flight diagram thus prepared, the best controlled strip is selected as the first to be laid down. It is an advantage if this strip has two control points fairly close together; this will thus give a scale to the assembly before many templates are laid down.

PREPARATION OF PHOTOGRAPHS

(a) Mark up the approximate North point on all photos.

(b) Mark all principal points and transfer them to adjacent photos.

(c) Select and mark minor control points and transfer them to adjacent photos. Whenever possible these should be selected common to adjacent runs to thus serve as lateral join points. If common minor control points can be selected on adjacent runs, a very rigid template assembly is assured with a minimum of identification and

slotting. If, for any reason, it is necessary to introduce points in addition to minor control points to provide the lateral join, one such point per photo is sufficient. Again, any ground control point, if suitably situated on the photos, should be used as minor control and join point.

(d) Check all photos to see that all principal points, minor control points, lateral join points, and ground control points are transferred to all photos in all runs in which they occur. This is an important step, as templates have to be discarded if incomplete when punching has commenced.

(e) Allot numbers to all points which are to be pricked through to the templates. Principal points and transferred principal points will carry their photo number, and minor control and join points may be numbered consecutively from one end of the photo run. Points which are common to two runs will of course carry the same number.

APPARATUS

The apparatus consists of the slotting and centre punching machines, together with ancillary equipment and material. There are two types of slotting machines and associated punches in use by the Royal Australian Survey Corps. The equipment is listed in detail as follows:

(a) Slotting Machine South African Pattern (Mk IV).

This machine (Figs. 5 & 7) cuts a slot 1½" long by .125" wide, radial to the centre point of the template, which is punched as a circular hole .125" diameter by the centre punch. (Fig. 6).

(b) Slotting Machine Local Pattern.

This machine cuts a slot 2" long by .150" wide radial to the centre point of the template, which is punched as a circular hole .150" diameter by the centre punch (Fig. 3) or by the adoption of the slotting machine by replacement of the cutting blade with a punch (Item (e) Fig. 2) . This machine requires two items of ancillary equipment peculiar to its use.

Pricker for-transferring photo-points to the templates.

Clip board of Masonite to hold the photographs in position when the point points are being pricked.

(c) Items common to the use of both pattern slotting machines.

(i) Templates

The templates are, prepared from cellulose acetate sheets or laminated bristol or paste board. The templates are initially cut 1" larger than the photos which are being used. Cellulose acetate templates should be used for 1 mile to 1 inch mapping and larger and the board templates used for smaller scale mapping.

(ii) Brass Studs

Brass studs which have a wide base and a shank which fits the slots or centre holes. Each stud has a centre hole for fixing its exact position.

(iii) Pins

Steel pins which fit the centre hole in the brass studs.

(iv) Shears

Shears for trimming the templates after cutting and before assembly.

(v) Sponge Rubber Mats

Mats used for kneeling during floor assemblies.

(vi) Assembly Table

Gridded table of wood or metal on which to assemble the templates.

The use of the South African Pattern Machine which has greater precision and is mechanically superior is preferable on standard map assemblies. The local pattern machine is faster in operation and permits of the cutting of larger templates. Its use should be confined, when a choice of machines is available, to standard mapping with scale requirements beyond the capacity of the South African machine and to the assembly of mosaics involving a large number of templates.

PREPARATION OF TEMPLATES FOR LOCAL PATTERN SLOTTING MACHINE

Pricking the Templates

The photo is placed over the template in such a position that all selected points are situated at least 1" inches inside the edge of the template board. This is to ensure that the radial slots, when they are cut, will not extend beyond the edges of the template. The photo and template are then clipped on to the clip board.

Each of the points is then pricked vertically through the photo far enough to make the prick mark just appear through the template. This should be done methodically to avoid missing any points thus: starting at the top left hand corner prick first the minor control and transferred principal points counting eight in all; then the principal point and any ground control and lateral join points which may be present. The starting point is then repricked, the clips removed, and the templates examined. If two marks appear on the template at the first point, it indicates that the photo has moved during the operation, and the points must be pricked again on a fresh template.

After pricking, the points on the template are circled and given the numbers already allotted to the points on the photos. Minor control and join points are circled and numbered in blue, the number being placed near the circle in such a position that it will not be damaged by the radial slot when it is subsequently cut. The principal point and transferred principal points are circled in red, and the run and photo number and approximate north point are added.

Radial Lining.

When pricking has been completed, the templates are examined to see if any points require adjustment before slot cutting. Where any point lies with 1¼ inches of the edge of the template or its centre point a fine radial line is drawn through that point. Similarly if two points, such as a minor control and ground control point, fall in such a position that it is apparent that their slots will overlap, radial lines are drawn to each point, and positions selected for the slots which will give sufficient room to each. If this is not practicable, it will generally be found on careful examination that the minor control point can be omitted and the ground control point made to serve also as a minor control point. On no account should the slots cut through the edge of the template or overlap one another.

Centre Punching.

Before punching, the templates are carefully examined by a senior member of the section to ensure that all pricked points are circled and numbered as described. The templates are then placed under the principal point punch, which is held vertical by the wooden guide frame. The principal point prick mark is placed exactly beneath the pin of the circular punch. The centre hole is then cut by giving the punch one sharp blow with the hammer.

Slotting.

The template is placed on the slotting machine with the sliding stud through the punched centre hole of the template. The template is then moved until the prick mark for one of the slots is exactly under the pin of the cutter, and the lever arm pulled down slowly until the pin makes contact with the prick- mark. The lever arm is depressed further until the cutting edge is resting on the card, and then the slot is completed by a sharp downward pull on the lever.

Extreme care should be taken to ensure that slotting is carried out to the greatest accuracy. Cumulative errors can be introduced with the assembly through carelessness of the operator, or through/the machine being out of adjustment, and it is only by constant supervision that errors can be reduced to a minimum. The alignment of the machine is tested by examination of one of the slot pieces cut out; its edges should be symmetrical about a radial line drawn through the pricked point before slotting. With a perfectly adjusted machine, a skilled and careful operator should cut out a slot piece whose sides are exactly equidistant from the original prick mark made in the template.

The slotting machine is a precision instrument, and it should not be used if the cutting blade does not pass cleanly through the lower die. If the blade bears unevenly on the ends or sides of the die a clean and precise slot will not be cut, and the blade will be quickly damaged. Experience has shown that a properly adjusted blade

will cut approximately 10,000 slots before requiring resharpening.

PREPARATION OF TEMPLATES FOR SOUTH AFRICAN PATTERN MK IV SLOTTING MACHINE

In the South African pattern machine the photo and template are clamped in a constant relationship. Movement of a common spindle and turntable ensures that the radial slot is cut in the template to conform exactly with the setting of the main cursor line through the selected control point of the photograph. Also the distance of the slot from the centre of the photo is set by selective setting of the cross cursor arm. The requirement to predetermine the position of the slots on the template by pricking through from the photo is eliminated. The cutting movement is actuated by foot pressure on a treadle. The corners of 10" x 10" templates should be trimmed, because a diagonal distance from the centre to the corner of the templates in excess of 7" will foul the turntable support arms of the machine.

The following procedure carried out in correct sequence will ensure successful operation.

(i) Punch the centre hole of the template using punch. (Fig 6)
(ii) Move the turntable to the IN position or at least sufficiently far back to expose the clutch nut.
(iii) Place the centre hole of the template over the spindle of the Clutch Nut taking care to place the curled templates with the concave side downwards.
(iv) Slide the turntable to the OUT position. This puts the spindle of the turntable directly over the Clutch Nut,
(v) Lift the clutch lever and hold in that position. This locks the turntable slide in position.
(vi) Rotate the turntable clockwise. The clutch nut will begin to engage and at approximately 2½ rotations a click will be heard which indicates that the card is held firmly between the clutch nut and the turntable spindle.
(vii) Release the clutch lever thus allowing the turntable slide to be moved into any required position.
(viii) Switch on lights. Place photograph on turntable symmetrically over the template and bring the principal point of the photograph into coincidence with the cross of the main cursor arm which is illuminated when turntable is near the out position. The photograph is fixed to the turntable with two clips on diagonally opposite corners. This still permits of some movement for the final setting of the principal point. Check the final setting by rotation of the turntable, before affixing remaining clips to the photograph.
(ix) Clamp the cross cursor arm in the position which gives the required template scale. When the cross cursor arm is at right angles to the main cursor the photo and template are at the same scale. The template scale is enlarged by moving the point of the cross cursor towards the centre of the photo. The scale is decreased by moving it away from the centre.
(x) Rotate the turntable until the main cursor line passes through the control point. Move the turntable lever until the photo point is coincident with the point of the cross cursor arm. Press treadle to cut the slot. Rotate and repeat for remaining photo points.
(xi) Mark the template with identification and control point references to conform to the photo.
(xii) Bring the turntable to the OUT position. Engage the clutch lever and rotate the turntable in anti-clockwise direction. This will release the clutch nut and permit free movement of the turntable to the IN position. The template can then be lifted off the exposed clutch nut in the base of the machine. Care should be taken to ensure that the clutch nut is fully disengaged before attempting to move the turntable from the clutch nut. This is important as the thread of the nut might otherwise be stripped.
(xiii) If the centre hole of the template indicates that abrasion or distortion has occurred during the slotting operation, discard the template.

ASSEMBLING OF SLOTTED TEMPLATES.

The templates of the strip selected as starting strip are taken, and the template containing two control points, or that containing one of the two nearest together is laid down. Studs are inserted in the centre hole, and in each slot except that of the control point which is already fixed in position on the grid. The template next towards the nearest control point is placed in position so that the stud in the slot towards its principal point engages in its centre hole. The other studs are slid along until they enter the appropriate slots of the new template. More studs are inserted in the empty slots of the new template. Take the next template and trim around the edges close

to the ends of the slots but without cutting them open. Holding the template with both hands, bend it slightly downwards in the middle, and engage its centre hole over the stud which is loose in its slot in the last template. Keeping the template bent, swing it until the slot to the previous principal point is over that stud and then slide the template and its stud to the right or left until the left hand minor control slots are over their studs. Then lower the left edge so that the three studs representing the minor control points abreast the principal point, in or out, until they engage in the slots of the template being handled, and lower this template down engaging any ground control or lateral join studs in their appropriate slots. This operation must be done without any forcing.

At this stage, the scale of the strip of templates is still undetermined, and difficulty may be experienced when the second ground control point is met. If the slot falls short of the fixed stud, gently pull the last principal point stud outwards with one hand, tapping the previous templates with the finger tips of the other, or gently pushing pairs of minor control studs apart with the span of the hand. The fewer the studs, the easier this operation is performed, and it is for this reason that the assembly is started between the nearest pair of control points.

Once one strip is laid down, the adjacent strips can easily be assembled since the lateral join provides the scale for new runs. If difficulty is experienced in fitting templates to join points, a slight bowing of the first strip may help, but force must not be used at any time. If any one template will not go down easily, it should be temporarily omitted, and the area worked around from another direction.

EXAMINATION OF ILL-FITTING TEMPLATES

The majority of errors are due to misidentified points or bad slot cutting. The case of a doubtful template should be examined as follows:

(a) Examine the photos for identification of minor control and lateral join points for three overlaps on each side.
(b) Check the correctness of the transfer of principal points for three overlaps.
(c) Place the doubtful template over its photograph with the principal point in the punched centre hole, and correctly oriented, and see if all points are central in their slots. If the slotting has been previously examined this is a test of the principal point punching only.
(d) If no errors are found in the templates it is then necessary to check the plotted position of adjacent ground control points. A faulty control point can often be found by inspection of the assembly, but such points should not be discarded without careful examination of all other possibilities of error.

PREPARATION OF COMPILATION SHEETS.

When the whole area has been satisfactorily assembled, sufficient nailing pins are inserted through studs around the edges to hold the assembly in position whilst minor control and principal point positions are pricked through on to the grid.

Starting at the last run of templates laid down, the positions of all studs are pricked through to the grid, by means of a fine pricker inserted down through the studs. This must be done systematically, and as points of each template are transferred to the grid board, the template is lifted and each grid point is circled, and numbered to agree with the original photo number allotted to it.

When this is completed, the grid board shows the position of each principal point and minor control point of every photo covering the area. Field sheets are then prepared for detail plotting by placing gridded compilation sheets in position over the grid, and pricking through all points required for the carrying out of the detail plot.

GRID TABLES.

The use of a duralium surface to obviate movement over the plotting area will necessitate the joining of several sheets of the metal, and their fixation to a wooden table or to the floor. The following method is suggested as one which has been satisfactorily applied to cover a 6' x 9' table top and to affix studs.

(a) The 3ft wide sheets are butt joined along their length by a 2" x ¼" soft iron strip to which they are screwed at 6" centres. Channels 2⅛" x ⅜" are cut across the wooden table top directly beneath the proposed join position of the duralium strips. The complete duralium top is then placed on the table top with the joining strips riding freely in the channels. If the duralium has not been bulged or unduly distorted from the horizontal plane, its weight will hold it in contact with the table and sufficiently flat for general plotting purposes. Should it be necessary to affix the metal to the wooden table, 1" No.6 wood screws are suitable for the purpose, and holes can be plugged with plastic wood, plastic steel, or putty.

(b) Surfacing of the duralium can be done by applying two under coats of "Permaseal" white paint followed by two coats of good quality flat white house paint. Undercoats should be well sanded and surface coats lightly sanded as necessary.

(c) Basic reference corners and grid lines are best drawn on the surface and erased and redrawn as necessary for change in scale and areas. The removal of inscribed line; whether on metal or undercoats presents some difficulty without complete re-surfacing.

(d) Control studs are fixed to the surface by glueing with albumen glue, sticking with cellotape, or by using both materials. The use of cellotape by punching short strips, slipping them over the stud and affixing them transversely to the table is quite successful.

CONTROL FOR SLOTTED TEMPLATE ASSEMBLIES

(a) In assessing the number and the positions of survey points to, control the slotted template assembly for a map area, fundamental requirements would be:

To afford a consistent density, or adequate degree of rigidity over the whole area.
To ensure the firmness of the plot of the perimeter of the map.
To keep the number of points to a minimum consistent with the above.

The number of points, or the density of control, would be influenced by consideration of map scale and scale of photography, i.e. the number of runs and photos, and by the availability of tie strips in the photography.

On the one hand, an assembly which relies on a bare minimum of control points with tie strips, and lacks internal stabilization, has a flexibility which induces a probability of error beyond the tolerance of large scale standard maps. This might be acceptable for small scale maps in remote areas. On the other hand, experience has shown that no practical advantage in accuracy is obtained by an extreme or saturated condition of control which is likely to occur in large scale map areas with favourable terrain.

(b) An examination of the control for a 1 mile standard map area (Fig. 10) which may be considered ideal will indicate the optimum. In this example the perimeter has been stabilized and internally a symmetrical and consistent allocation of control has been achieved. Eighteen points have been used and control has been established on at least every 4th photograph. Twelve of the points directly afford control to 2 runs in each case. More points would not add to the accuracy of the assembly, and would introduce unnecessary difficulties and labour in assembling.

The physical conditions governing the survey of all areas will vary so that departure from the ideal can be anticipated in most cases. However, if the fundamental principles of the assembly and the requirements for its control, together with a picture of the ideal are kept in mind, departure in the direction of too much or too little control, to meet the requirements can be kept to a minimum.

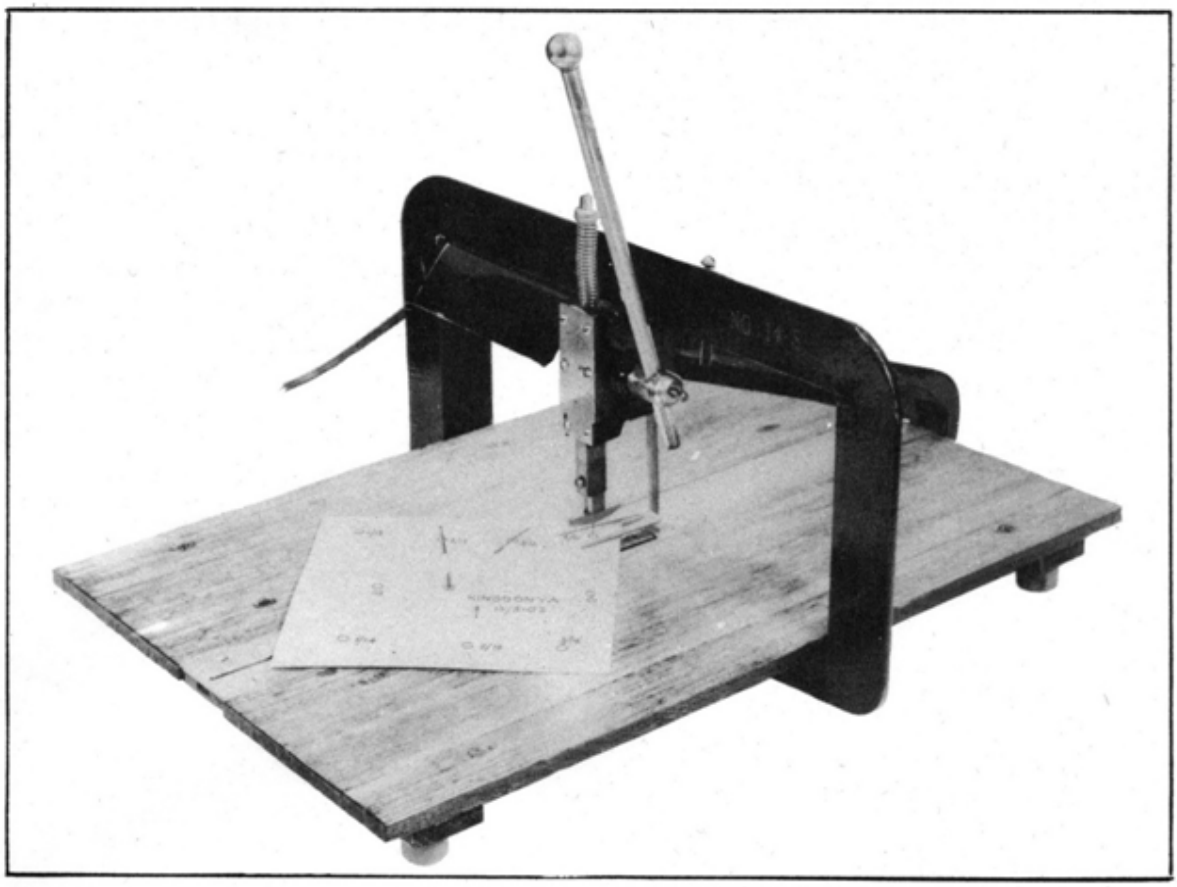

Fig 1 Slotted Template Machine
Local Pattern

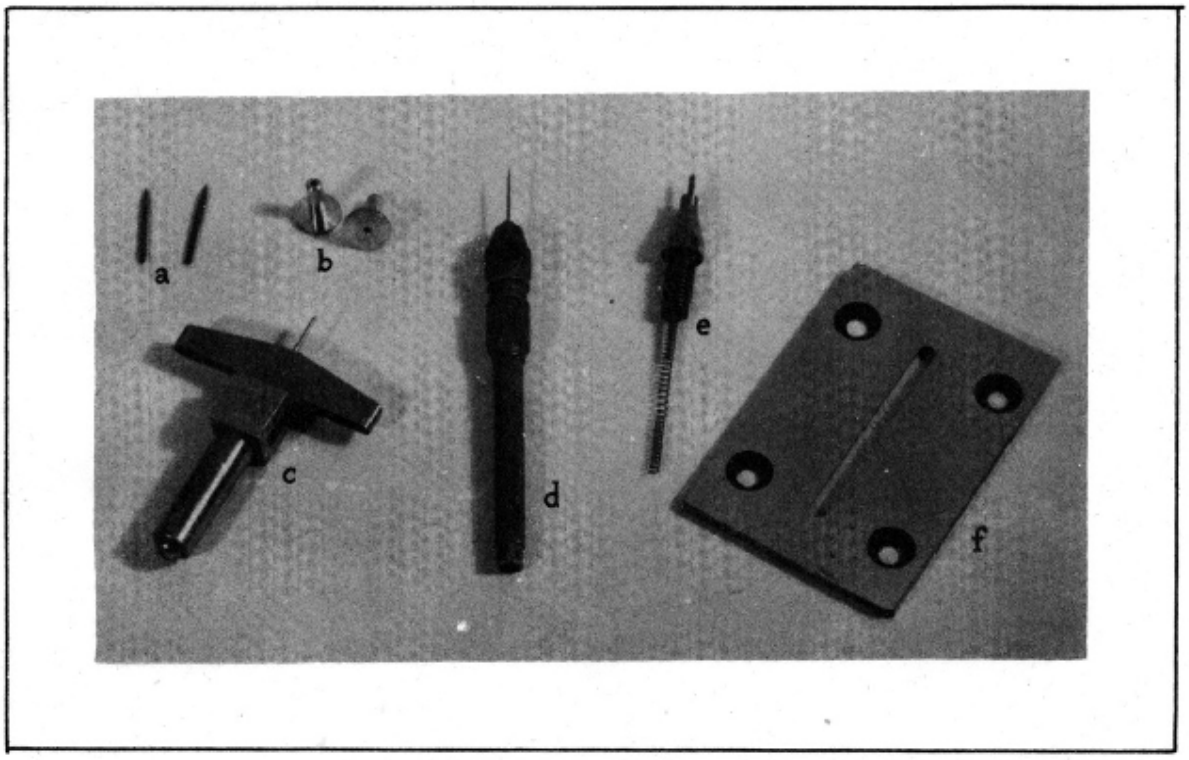

Fig. 2 (a) Nailing pins of hardened steel
(b) Brass Studs
(c) Slot cutter with retractable centre pin
(d) Pin Vice and fine pricking needle
(e) Centre hole cutter with retractable centre pin
(f) Hardened steel die.

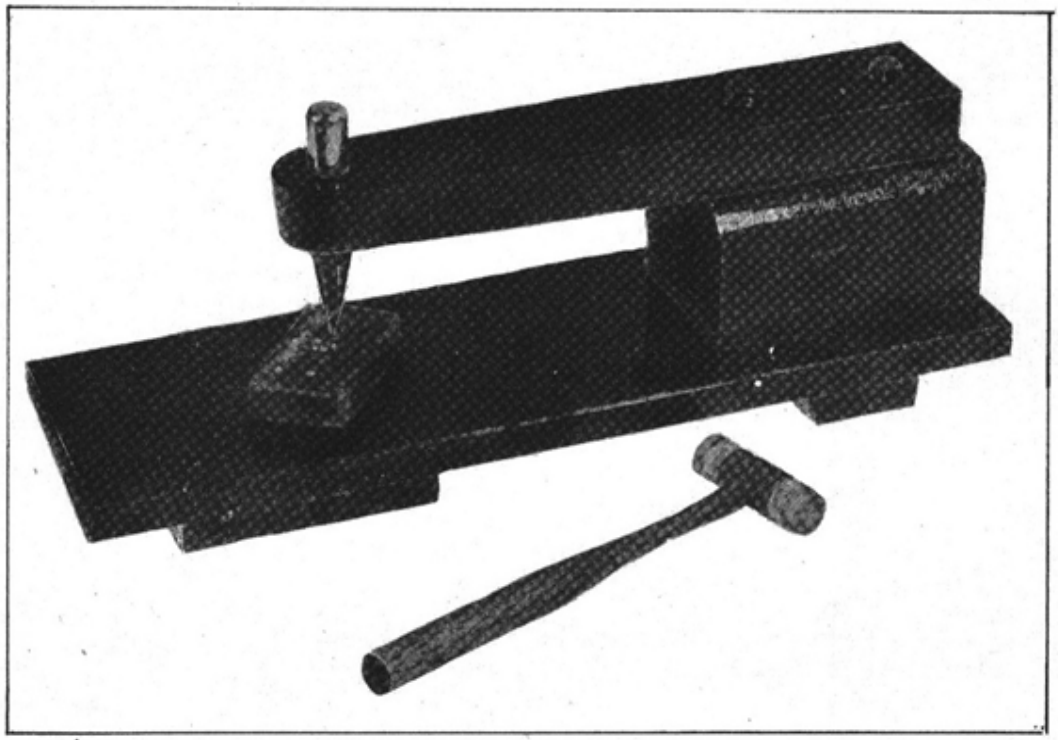

Fig. 3. Centre Punch - Local Pattern
Note: Lead base block under centre punch.

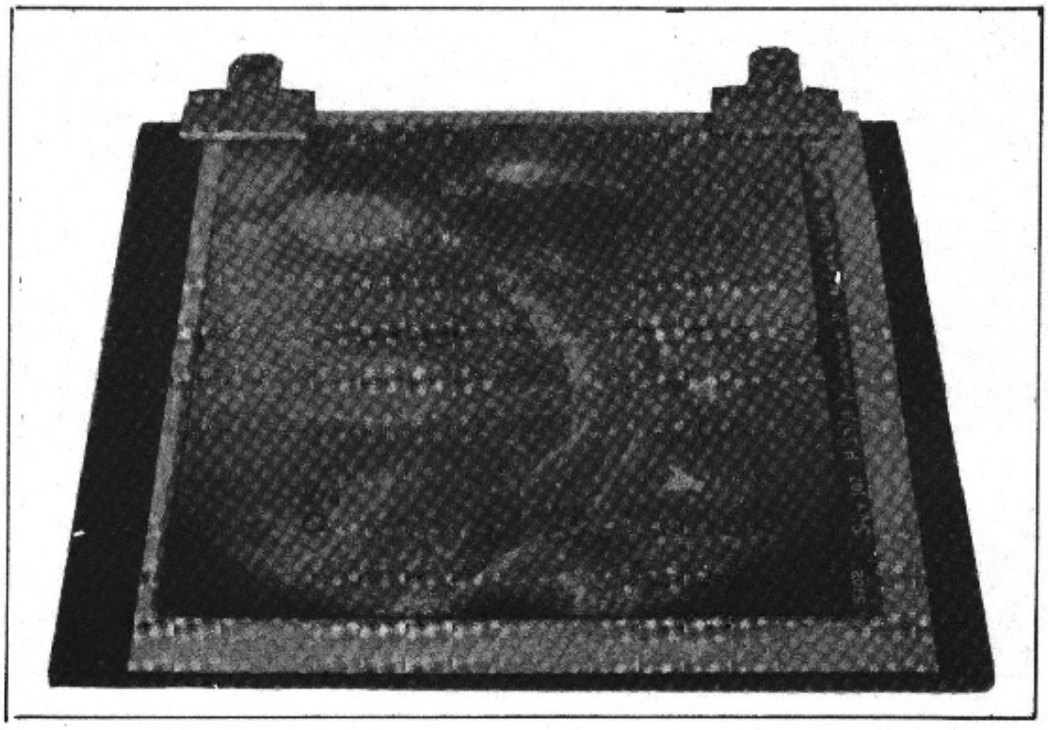

Fig. 4. Photo clipped over Template card on
Masonite Clip Board

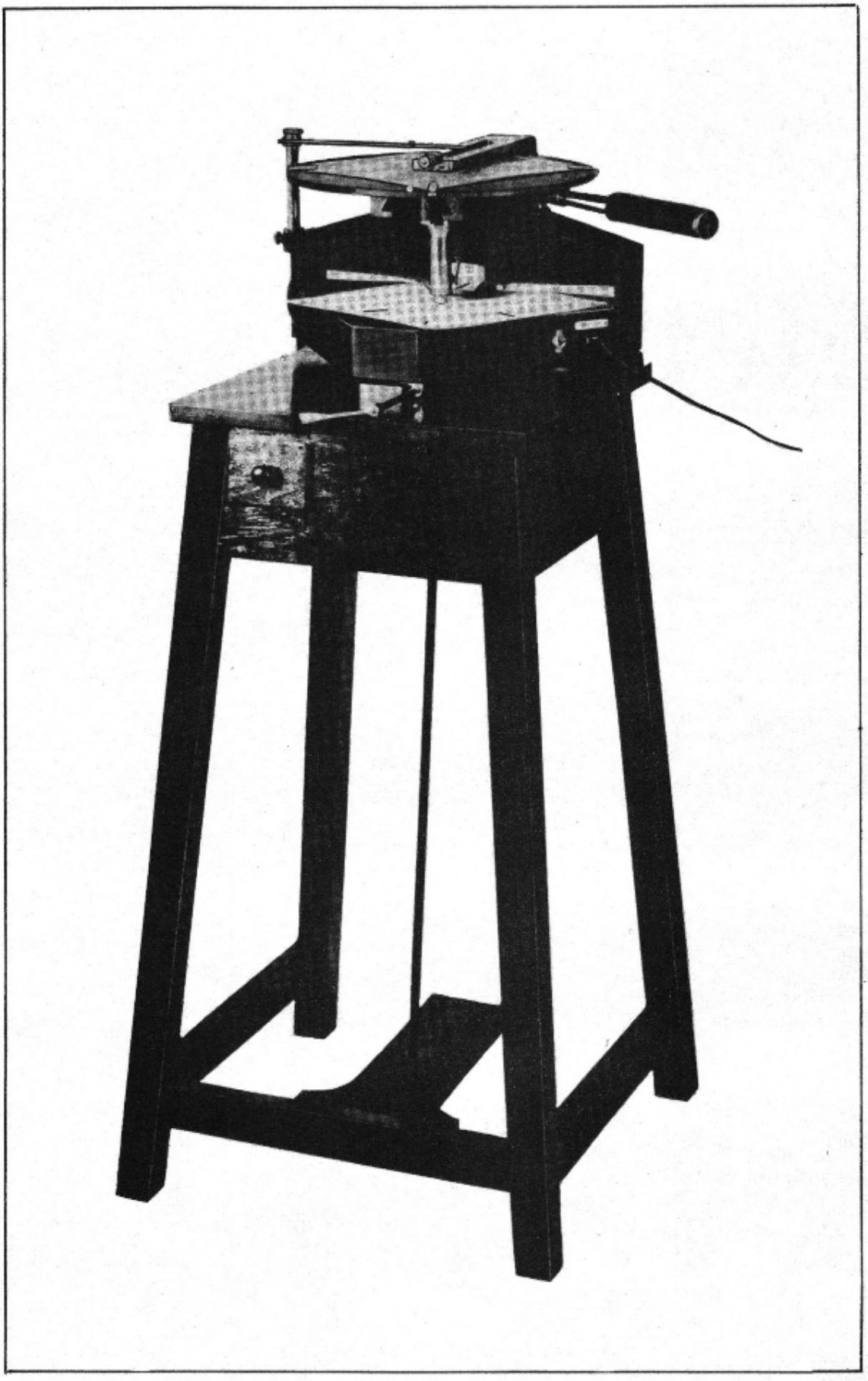

Fig. 5. Slotted Template Machine
South African Pattern Mark 1V

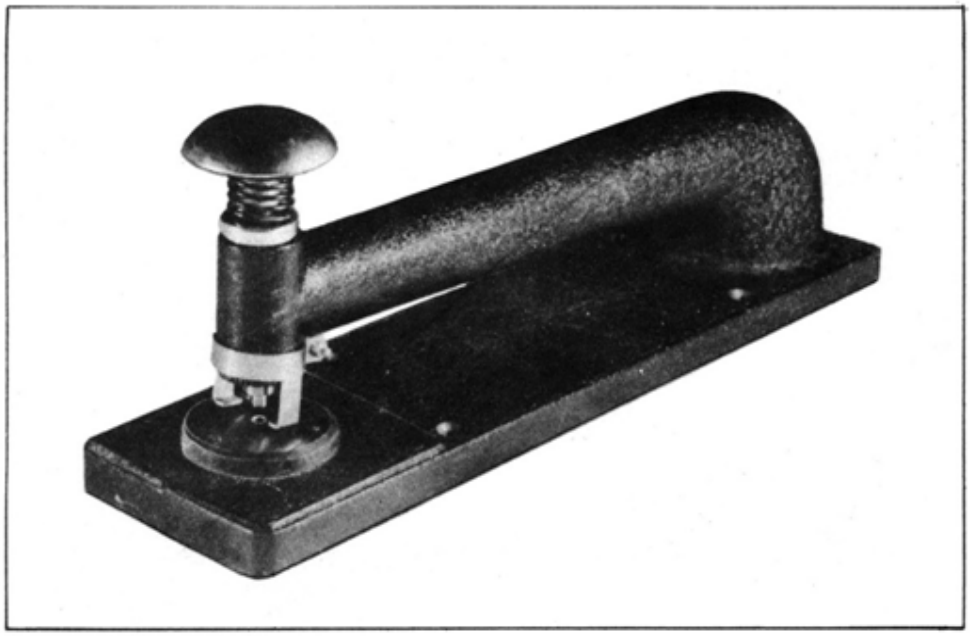

Fig. 6. Centre Punch
South African Pattern

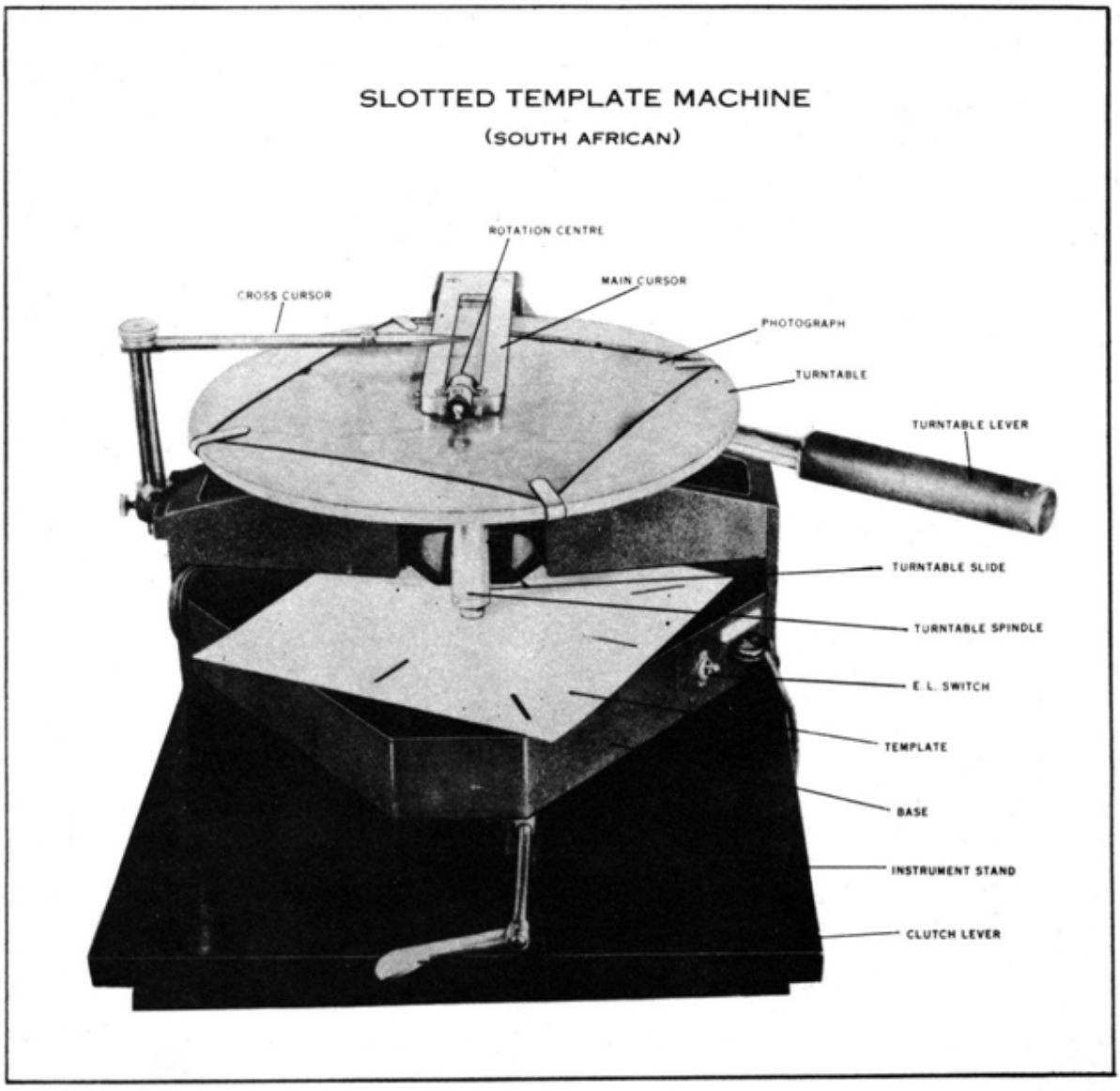

Fig. 7. Slotted Template Machine
South African Pattern MK 1V

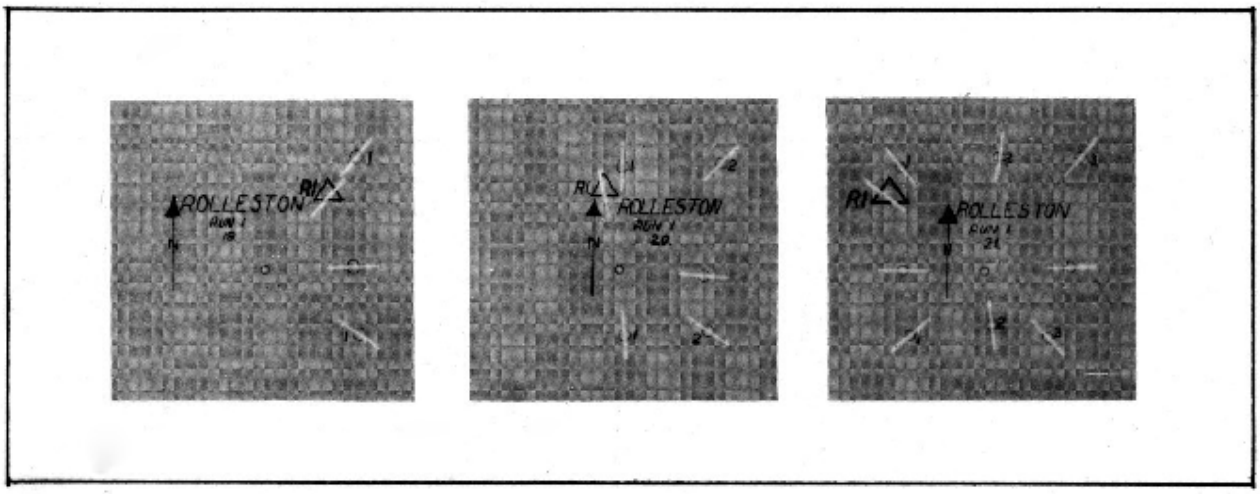

Fig. 8. Three consecutive Templates showing slots cut to ground control and minor control points.

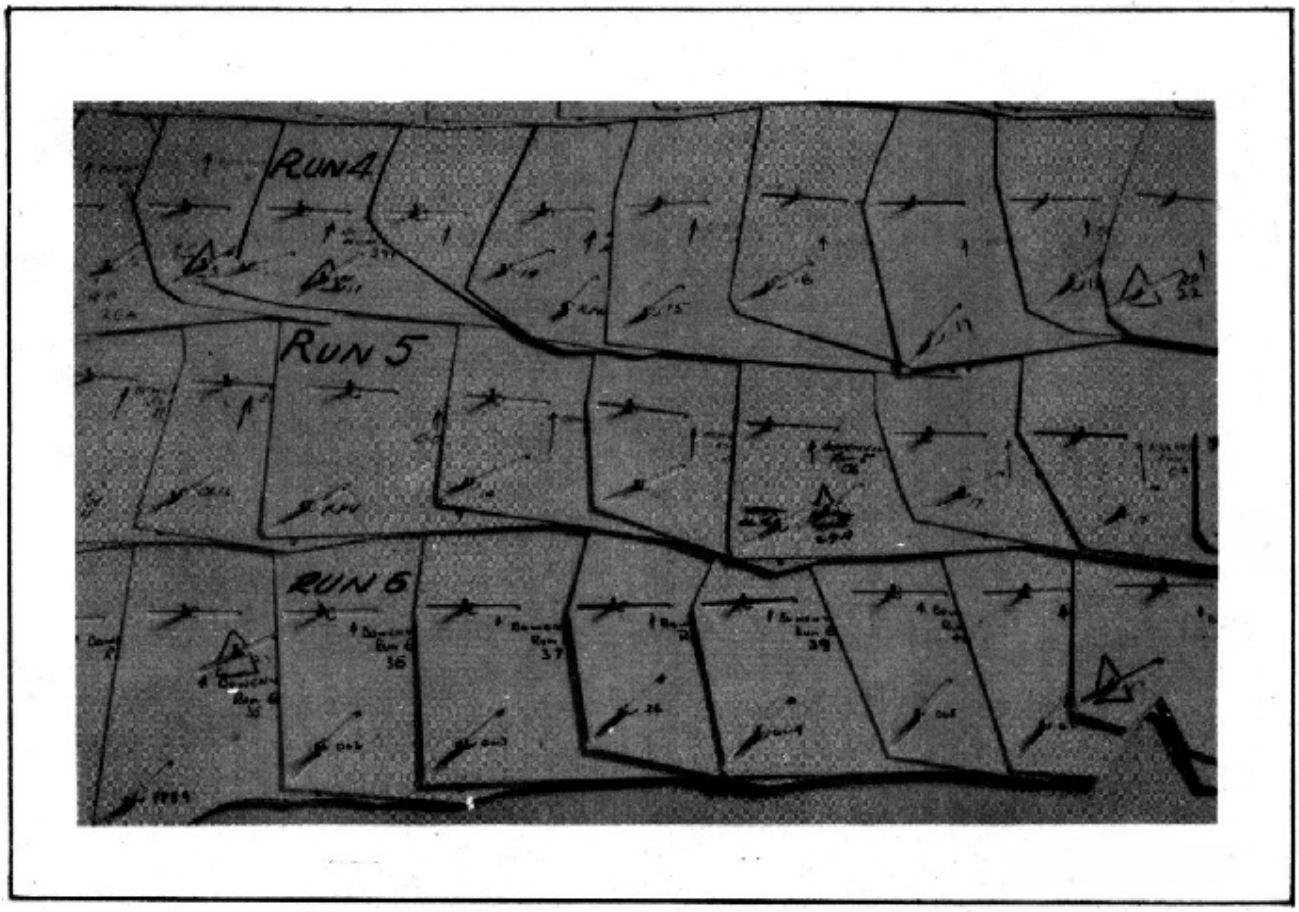

Fig 9. Templates assembled to ground control on grid board.

APPENDIX A

DIRECTION RAY METHOD OF CONTROL FOR SLOTTED TEMPLATE ASSEMBLIES

GENERAL

When surveyors are establishing photo control for mapping, they can often see points from one trig station which are satisfactory as control points, but which are not visible from other trig points. As these positions cannot be fixed they are not used.

Single directions or rays can be used in conjunction with fully coordinated points to control slotted template assemblies (Fig 11). This is done, by incorporating the rays through identified points into the assembly, by means of control studs set in slots and free to move only along the direction of the rays. In this way, single directional rays through identified points of detail, exercise control of scale and azimuth within the assembly, which is normally done by properly coordinated points.

PROCEDURE

(a) Reconnaissance: The photos of the area to be mapped are examined in conjunction with established or planned trig points, and the requirements for photo control for the template assembly are assessed. Field reconnaissance will indicate whether or not the control points can be readily and economically established by the usual methods of resection, intersection and traverse. In areas where normal control will be difficult, single rays can be made from the trig stations to selected identifiable points.

The single rays should ensure that control for the template assembly is provided in all directions; i.e. if a ray were observed in an NS direction to a point, this should be balanced by a ray to a point in an EW direction. The rays need not be taken from the one trig station, but should be planned so that they exercise opposing forces on the movement of the slotted template (Fig 12 refers)

(b) Field Observations & Recording: The point to which the ray is observed should be accurately identified on the photo and should be given a number in the observation book, definitely associating it with the photo and run on which it occurs, The use of a mosaic, even if roughly made and localised, is a considerable aid in identification of points.

The direction should be observed to fourth order accuracy, two rounds with 0° & 45° as zeros and referred to a known azimuth, being required.

In certain circumstances it may be practicable to arrange for a moving party to visit various points to which single rays are to be observed, and to present a target to an observer at a central trig station. This party can positively identify the point of detail on the photo.

(c) Computation and Plotting of Rays in the Template Grid: The azimuth of the observed ray is computed by reference to the known bearing of the RO. The approximate position on the grid table of the point observed can be located from the azimuth and from the distance scaled on the photo or mosaic. The direction of the ray is accurately plotted through or near the approximate position of the point, either by using a large circular, projector centered on the trig station, or by computing cutting lines on the adjoining 1,000 yard grid lines and joining the cuts.

The distance of the point from the trig station will probably indicate which of the two methods should be employed to ensure the required accuracy.

(d) Sliding Control Stud: (Fig 13) As the single ray fixes only the direction of the point from the trig station, provision has to be made for a moving control stud which can move only along the direction of the ray. A continuous slot, approximately 2½" long is cut in a piece of clear acetate. A control stud is inserted and the acetate is fixed to the grid table with cellotape, so that the center of the slot lies exactly along the plotted ray, with the stud in the approximate or estimated position of the point. The acetate strip should be of sufficient width, approximately 1" to enable it to be satisfactorily fixed to

the table and at the same time allow the stud freedom to move along the slot.

(e) Assembly of Templates: The observed points are identified on all adjoining and overlapping photos and the templates are cut and assembled in the normal way. Care should be taken during assembly of the templates to ensure that the studs adjacent, do not foul the acetate of the directional ray stud. If a number of studs are given a slight bevel on the bottom edges of their bases they will ride over the cellotape and can be used in the near vicinity of the acetate strips.

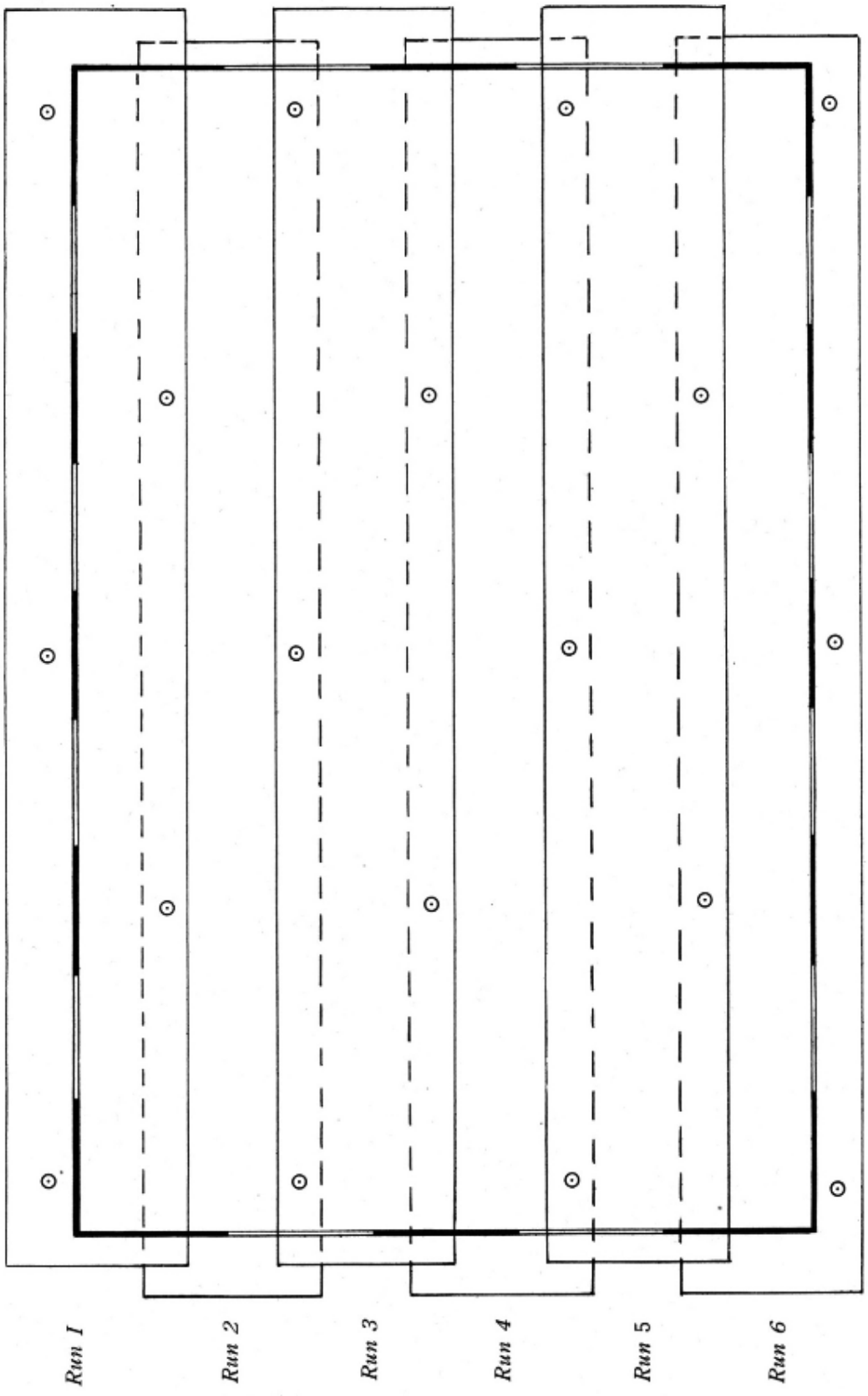

Fig. 10 Ideal control for standard 1 mile map area, covered by 6 runs, each of 20 photos at a scale of 1:31,680

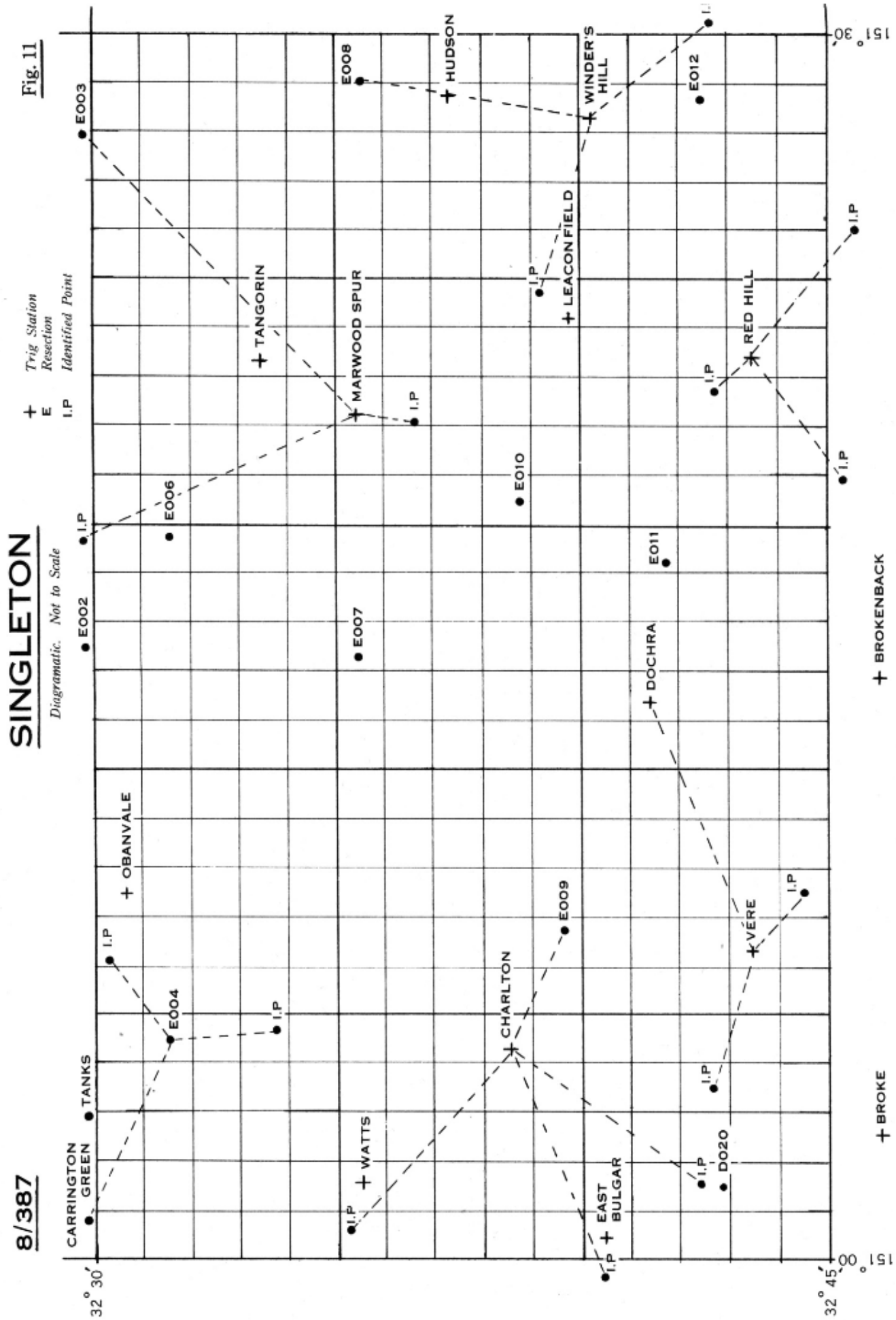

Fig. 11 Single direction rays used in conjunction with fully co-ordinated points to control a slotted template assembly.

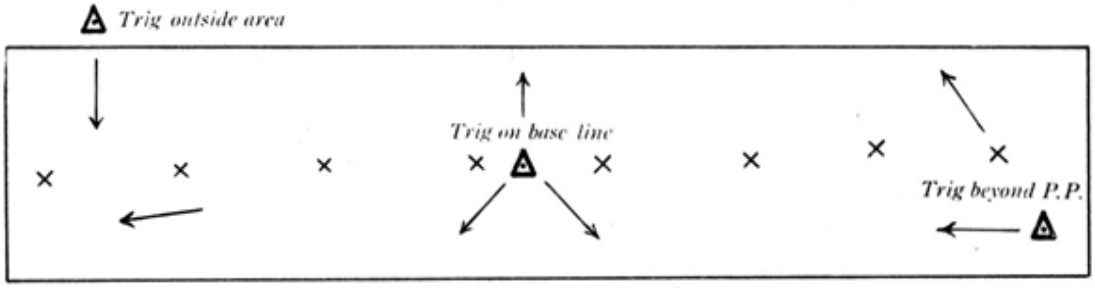

Fig. 12 Illustrating the control which can be exercised on a run of photos by single rays to stabilize it in scale and azimuth.

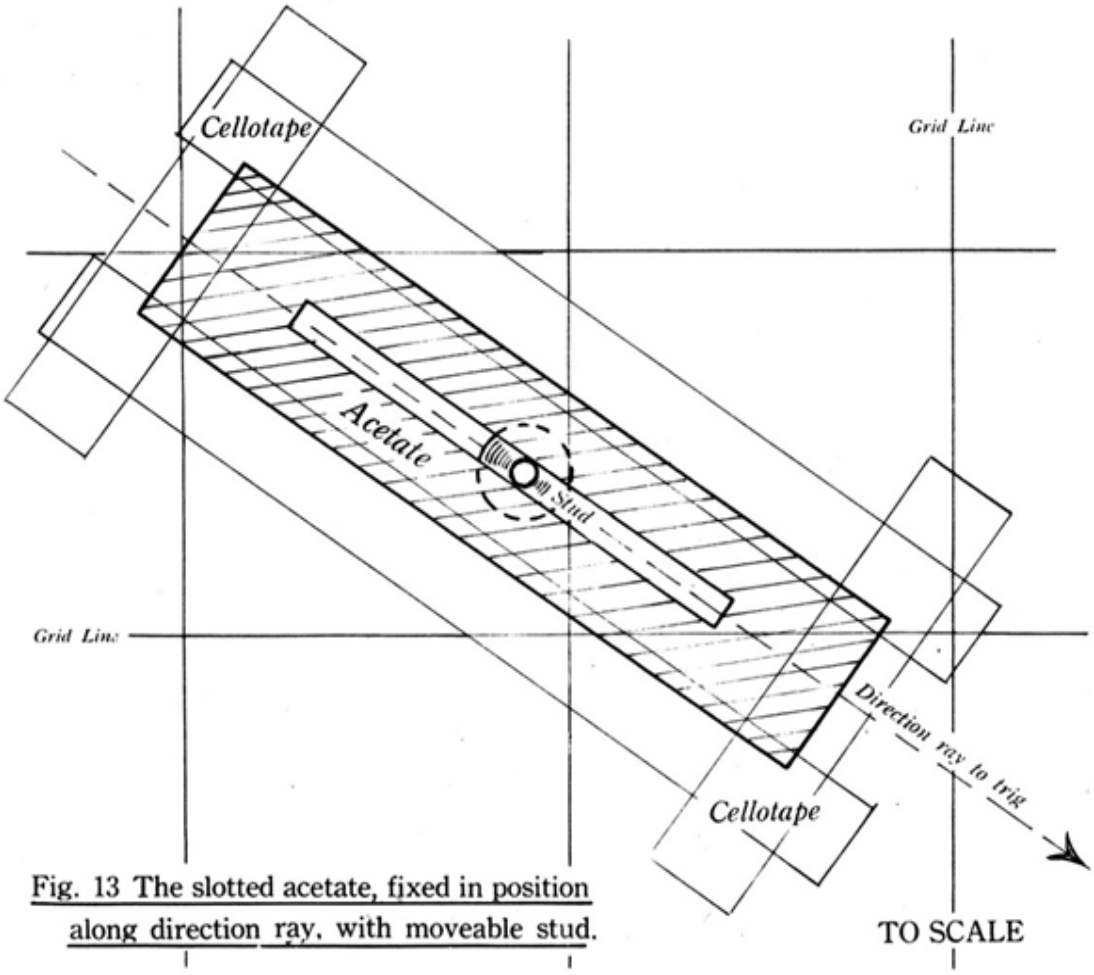

Fig. 13 The slotted acetate, fixed in position along direction ray, with moveable stud.