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GROUND PHOTOGRAMMETRY
AND ITS ADAPTABILITY

Thesis for the Degree of B. S.

MICHIGAN STATE COLLEGE

H. J. Anderson — P. J. Walters

1948

THESIS

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Ground Photogrammetry
and
Its Adaptability

A Thesis Submitted to

The Faculty of
Michigan State College
of
Agriculture and Applied Science

by

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Candidates for the Degree of

Bachelor of Science

June 1948

THESIS

2022

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DEDICATION

Dedicated to the faculty members of the
Civil Engineering Department of Michigan
State College whose help and guidance
during the past years have made this
thesis possible.

ACKNOWLEDGEMENT

The authors would like to express their heartfelt appreciation to Professor Leo Nothstine for his helpful advice on the various difficulties encountered in this thesis. His keen and sincere interest in our problem made working with him a distinct privilege.

Sincere thanks also to Hal McDavid who willingly gave his time to help us take, develop and print the pictures used as a basis for this thesis.

The authors are also extremely grateful to the Civil Engineering Department for the use of their equipment, and to the Abram's Aerial Survey Corporation and the Geology Department of Michigan State College for their kind help and advice.

Ground Photogrammetry and Its Adaptability

Introduction

"A map is a representation of any portion of the surface of the earth, on a plane surface, for the purpose of showing on a convenient scale the relative positions of points and natural features on the earth." Since man first realized that the earth was round, map making methods have developed rapidly. Time spent in the field and in the office has been decreased. The distortion due to the projection of a spherical surface on a plane has been greatly reduced. The advent of the aerial camera has allowed large areas to be mapped quickly and economically. These and many more are the rapid strides that have been made in the art of map making. However, one of the least known and least used methods of map making is that of Ground Photogrammetry. This extremely rapid method of map making was suggested as early as 1759, but it was not until 1859 that a French Army Colonel, named Laussedat, perfected methods which put photogrammetric surveying on a scientific basis. Ground Photogrammetry has long been secondary in importance to the various other map making techniques, but it is hoped that this thesis will destroy the illusion that the use of ground photogrammetry for map making is extremely difficult. Hence, this thesis was undertaken with the intention of securing a simple, rapid, accurate, and inclusive method of mapping a particular area through the use of a

ground camera. Although it is not attempted to minimize the importance of the finished map, it is the simplified steps leading to the completion of such a finished product that are of prime significance. Not only these simplified steps but also the difficulties that were encountered with their suggested remedies are included. It is hoped that Ground Photogrammetry will soon take its place among the often used map making methods. It was with this thought in mind that the following thesis was written.

Procedure

The procedure followed was very simple. A transit-stadia traverse of the area was run, care being taken in selecting stations that would give a clear view of the features that were to be mapped.

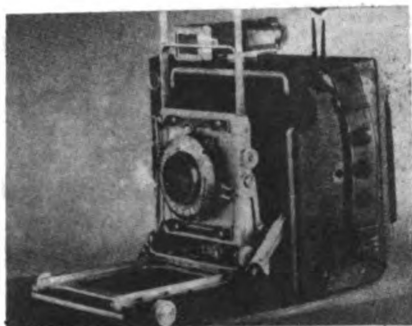
A Speed-Graphic camera f-4.5 as pictured was selected to run the survey a hairline was drawn on the viewing plate. A tripod with a mounting board was used. Level bubbles were mounted on this board at right angles to each other.

At first, it was believed that pictures covering the entire 360° around each station would be necessary. However, it was soon realized that some of the pictures would be needless duplications, and others would cover that ground outside the area of interest. At each station, the area to be photographed was determined by observation. Before the actual pictures were taken, range poles were set at each station.



Speed Graphic Camera

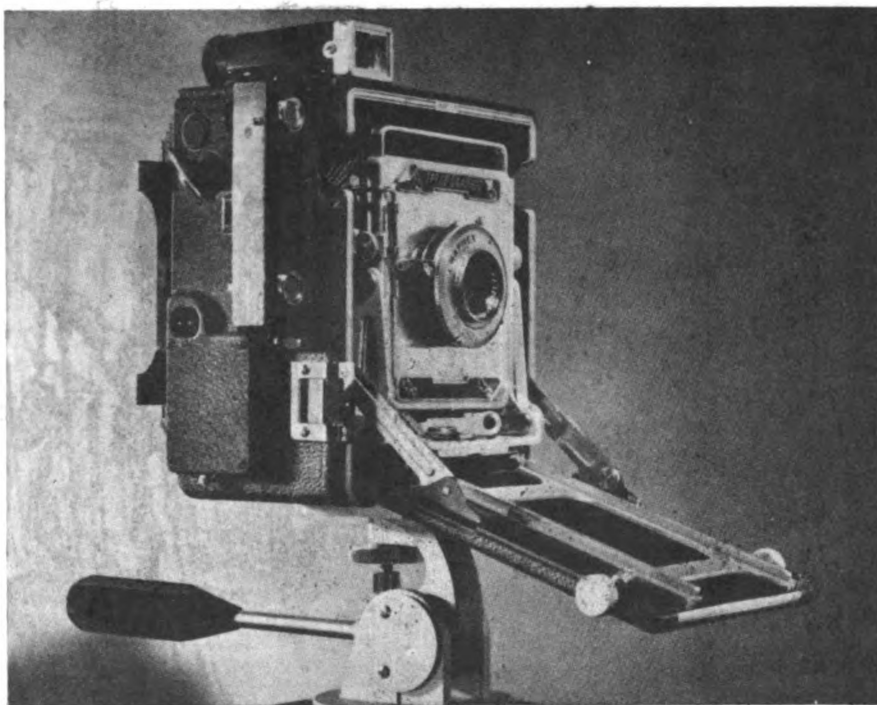
f - 4.5



-A-



-B-



-C-

Various views of the camera used.
Note the hairline in 'B'. This was
one of the improvisations previously

The camera was then set up and leveled over a station. To orient it, a sight was taken through the viewing glass, and the hairline on the viewing glass was centered on the range pole at the next station. The first picture was then taken. The camera was then pivoted horizontally in either direction until some prominent feature had moved across the plate to a similar position on the opposite side. This provided the necessary overlap. As soon as the required pictures were taken at one point, the camera was moved to another station, and the above process was repeated. At each point, the height of camera was measured. The focal length was kept constant at 135 mm. When the last picture was taken, the field work was completed.

The pictures were then developed, and contact prints were made.

The transit-stadia traverse was balanced, and plotted on a scale of $1'' = 100'$. This scale was selected because it allowed plotting that was contingent with the accuracy obtained in the field. It was also selected because of its convenience in fitting into the finished thesis. A copy of the traverse was made on tracing paper for each of the five stations. About the station assigned to each sheet, a circle with a radius of 135 mm. was drawn. Using the print that had been oriented, the bottom of the print was mounted tangent to the circle at the intersection of the circle and the traverse line. The remaining prints were placed by locating a feature common to it and the adjoining print. A

vertical projection of the feature was then brought to the bottom of the prints. The print was then oriented by placing the points of projection together, and, then by swinging the print until it was tangent to the circle at its center. This procedure was followed for all pictures of each set.

Projections of various features were then brought down to the bottom of the print, and radial lines were drawn from the station at the center of the circle through the points at the bottom of the print. The same features were located from another station. Radial lines were drawn through the projection points in the same manner. One set of radial lines was then placed on top of the other set. The sheets were oriented, and, through the tracing paper, the intersection of the radial lines from the stations to the projection points of similar features could be clearly seen. The points of intersection were noted and plotted on the sheet that seemed to contain the area that included the most features. From these intersections, the features were plotted on the various sheets as each feature was plotted, its radial lines were erased to prevent confusion. Upon completion of the plotting, the various sheets were placed beneath the master sheet, and the final map was completed.

There is little doubt in the minds of the authors as to the speed with which the field work may be accomplished. An area may be completely and adequately covered in one working day providing the crew knows what is to be done.

The crew should contain a man to carefully select stations that will give the coverage desired. This man may or may not be a part of the crew that runs the transit-stadia traverse.

While the transit-stadia traverse is progressing, several men should be marking points of interest and also marking the ground at intervals that are visible from two or more stations. Such action would make it easier to identify the various features, and it would make it possible to place contours on the map.

The camera crew, consisting of one man, could then move into position and take the required pictures. By observation, he could tell the area to be photographed from each station.

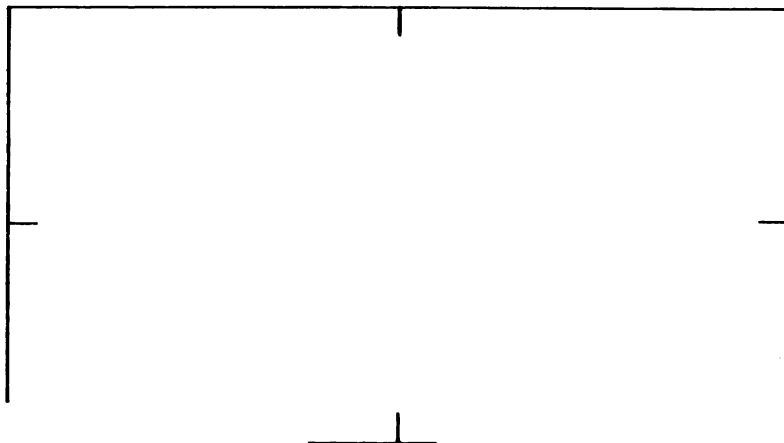
Note that no distances are needed except those obtained by the transit-stadia traverse. Buildings, roads, sidewalks, and other such features need not be measured since they are obtained by the method of intersection.

The difficulties encountered in the field were, for the most part, of a nature that would be corrected if more capital were available to obtain proper equipment.

The tripod that was used had a board mounting with no adjustments. The only possible way to level the camera, was to shift the tripod legs. This condition could have been corrected, however, by attaching the board to a three screw leveling device such as is used in precision survey work and mounting this on a transit tripod. The bubbles used were common level bubbles set on the board at right

angles to each other. These were particularly hard to manage since they couldn't be permanently mounted on the board due to the fact that the tripod, board, camera, etc., were borrowed. A spirit level mounted directly on the camera would solve this problem and allow for precise leveling. With these two refinements, the setting up of the camera would constitute little problem.

As was previously stated, the camera was borrowed, hence, it was impossible to mark or add marking devices to it. For this reason, only the plate was marked with a pencil line. Orientation was, therefore, accomplished by centering the first picture at each station on the range pole at the next. As a result, the tangent point of only one picture was known, and this only from a feature appearing on the print. Since it was not intended to extend this problem beyond the time available, the plotting of contours was not included which accounts for the omission of the horizontal cross hair. Now, if the camera were to be used for this type of work, it would take little effort to install projections on all sides of the camera. These projections would show up on all prints and would accurately mark the geometric center of each print.

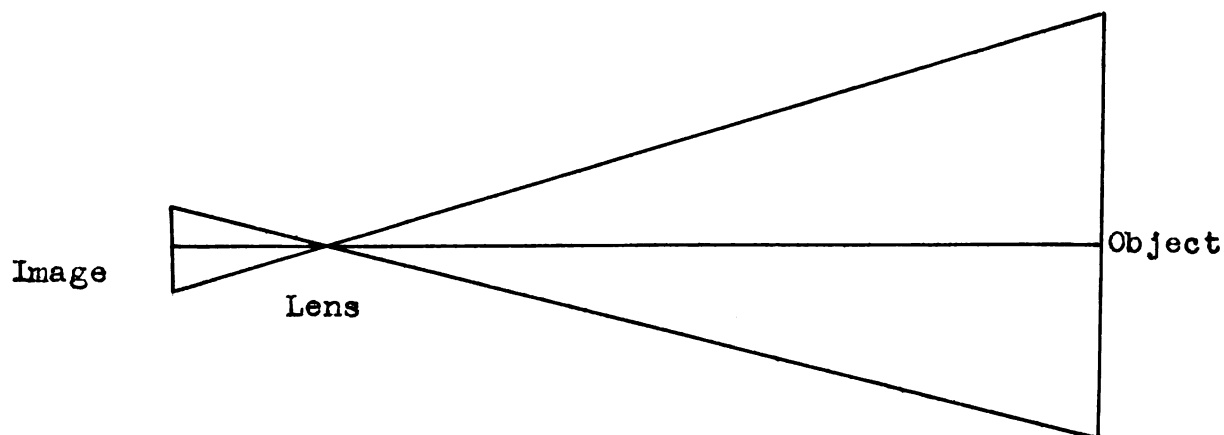


These projections would provide an accurate check as to the exact point of tangency and would also allow the more accurate calculation of elevations.

The focal length of the camera was kept constant, and the camera was of such a type that this was easily accomplished. However, this is an important point to remember when selecting a camera.

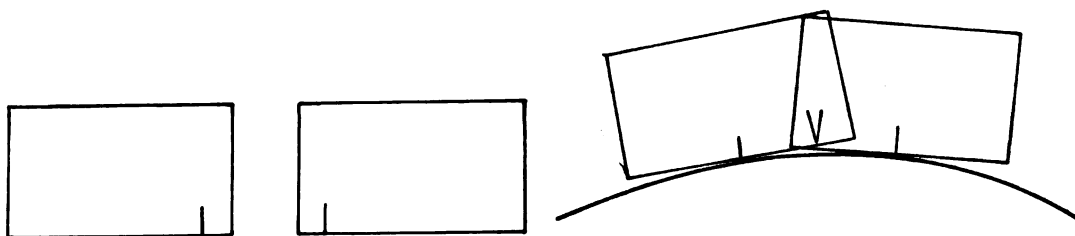
Moreover, choose as wide an angle lens as is possible since this greatly reduces the number of shots and, consequently, decreases the time involved and the cost.

It is necessary that contact prints be made of all shots. This is necessary to keep the correct ratio between the focal length and the actual distance on the ground. Little thought need be given to this to see that it is so. The contact print is the same size as the negative which is the image of the scene. This image is in proportion to the actual scene as the focal length is to the actual distance. Therefore, to keep everything in this ratio, the print must be the same size as the negative.

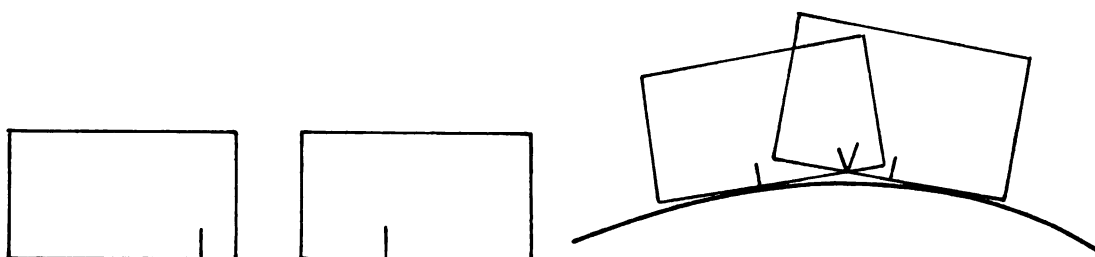


Overlap must be maintained, and, if a distinct feature is used, the distance it appears from the end of each print must be kept equal. Thus, the plotting and orienting of the pictures is greatly facilitated.

Several slight difficulties were encountered in plotting. First, since only the geometric center of one print in each set was noted, it was necessary to rely on overlap to correctly orient the remaining prints. It was found that, unless the feature selected for overlapping was of equal distance from the edge of each print, the point of tangency would not fall at the center of the print.



Correct



Incorrect

Therefore, incorrect orientation makes accurate plotting impossible.

This difficulty could easily have been overcome, had the geometric center of each print been marked. However, if care is taken in selecting

overlap points which are of equal distance from the edge of the pictures, this difficulty is easily remedied.

At first, a series of features was located, and radial lines were drawn on two preliminary sheets. However, the radial lines became too numerous and confusion resulted. Consequently, radial lines were drawn to widely diversified features. The features were located, and, immediately, the radial lines were erased. This allowed certainty in using the intersection of the correct pair of radial lines. In the long run, it not only saved errors in plotting but also speeded up the process by lessening the confusion.

Difficulty was encountered in the accurate identification of individual trees. This could be remedied, however, by marking the trees with some sign visible from two stations. In the case of groups of trees, the trees at the extreme ends could be so marked. These could then be easily plotted, and, from careful study of the pictures, the remainder of the group could be filled in. When it was impossible to identify a tree from two stations, it was still possible to plot it by using one radial line and by referring to some feature that had already been plotted. For example trees lining a road or river, or beside a building could easily be plotted by drawing their radial lines until they crossed the feature already plotted. Then using a relationship obtained from the pictures, the trees in question can easily be plotted.

Rivers and roads may be plotted by finding points on them and joining the points. Any change in direction should be noted, otherwise

only enough points are needed as will show location, direction and width.

Although elevations were not determined, they would ordinarily be calculated in the following manner. As has previously been noted, there is a definite relationship between actual distance on the ground and the focal length. The same relationship exists between the distance above or below the horizontal line through the geometric center of the print and the difference in elevation of the point in question and the center of the camera. The height of the center of the lens was noted in each case and a line of levels, taken during the transit-stadia survey, established the elevation of each station.

If the geometric center of each print had been marked, all vertical measurements could be scaled directly from the print. However, since this was not done, it was necessary to find the geometric center graphically before scaling.

When the elevation of a certain point is to be found, its horizontal distance - y is scaled directly from the map. The vertical distance above or below the horizontal center line is scaled directly from the print. Call this distance x . The focal length was known to be 135 mm. The difference in elevation (D) between the center line of the lens and the point in question can be found by solving the following relationship:

$$\frac{x}{135} = \frac{D}{y} \quad \text{or} \quad D = \frac{xy}{135}$$

Since the height of the center of the lens is known, the elevation of the point may be found by adding or subtracting D to it.

Because it seemed evident to the authors, the following important point was omitted in the set up procedure. It is the lens of the camera that is set up over the station and not the center of the camera. This is quite obvious when it is realized that the relationship between the focal length and the actual ground distance must be exact to correctly plot by intersection.

There are numerous reasons for the adoption of a photographic survey such as this.

The field work can be completed in one day, and, upon completion of the field work, detailed information has been obtained that a note keeper could never observe.

Distances and elevations need not be determined since these are taken care of by intersection of the radial lines and the horizontal line on the print.

The office crew, through the pictures, have a complete and thorough comprehension of the area even though they've never seen it personally.

An attempt has been made to give the reader a simple insight into the use of the camera for surveying. A simple and clear outline of the steps required for such a survey have been advanced. Difficulties with their suggested remedies have been put forth. These along with pictures, sketches and illustrations go to make up this thesis. It is

hoped by the authors that the myth of difficulty attached to this type of surveying will be dispelled, and that Ground Photogrammetry will soon come into common usage.

Illustrative Example

Determination of Elevations



Point 'B' measures 0.11 inches below the horizontal line in the above print. The above picture was taken from Point 'A'.

Camera lens at Point 'A' was 4.9 feet above Point 'A'.

Distance A-B was 345 feet.

f- 135 mm. or 5.315 inches

Therefore:

$$\frac{0.11}{5.315} = \frac{X}{345}$$

$$X = 7.2'$$

Elevation of lens at Point 'A' - 844.3 plus 4.9
or 849.2 feet

Elevation of Point 'B' - 849.2 minus 7.2 or

842.0 feet

TRANSIT - STADIA TRAVERSE H.J. ANDERSON
 MICHIGAN STATE COLLEGE P.J. WALTERS
 APRIL 10 1948

PT AT	STA	CORR. DIST.	AZ. ANG	ROD READ	VERT. ANG	ELEV
A	B	345'	62°58'	—	—	844.3'
	C	599'	111°24'	1.1'	+0°07'	
B	A	345'	242°58'	2.55'	—	841.8'
	C	423'	77°27'	7.96'	—	
C	B	423'	257°27'	1.73'	—	838.7'
	E	496'	199°22'	2.55'	0°52'	
	D	632'	91°47'	9.75'	-0°10'	
D	C	632'	271°47'	1.0'	+0°04'	833.3'
	B	1048'	266°03'	1.0'	+0°27'	
E	A	599'	291°24'	—	—	849.5'
	C	496'	19°22'	—	—	

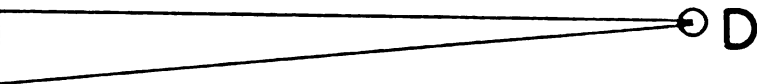
NOTES

ALL AZIMUTHS—CLOCKWISE FROM NORTH

ELEV. TO NEAREST ONE TENTH FOOT

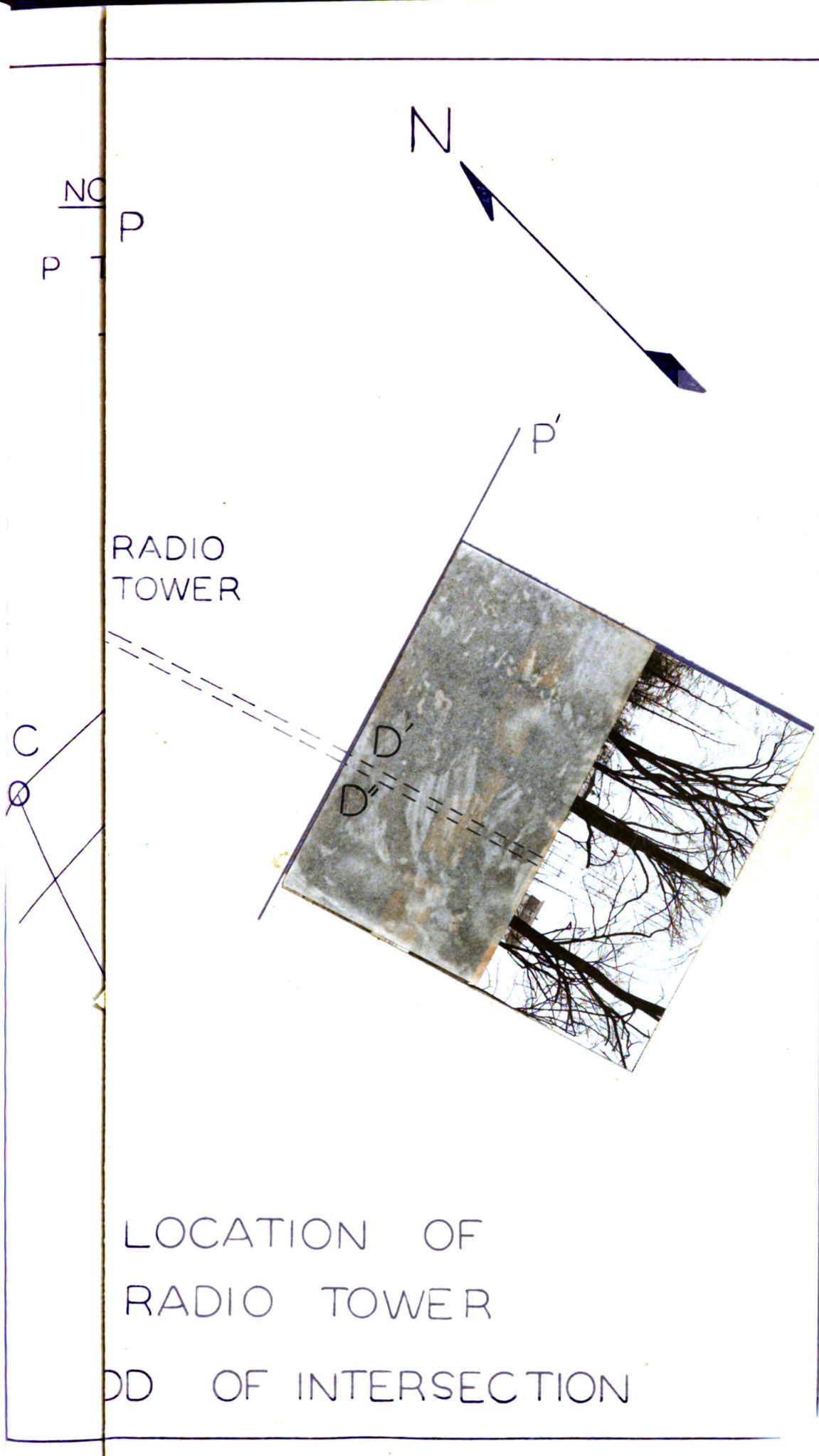
ELEV OF B.M. 839.65 FT.

SHOT ON BM FROM B - 714' H.I. - 5.03'



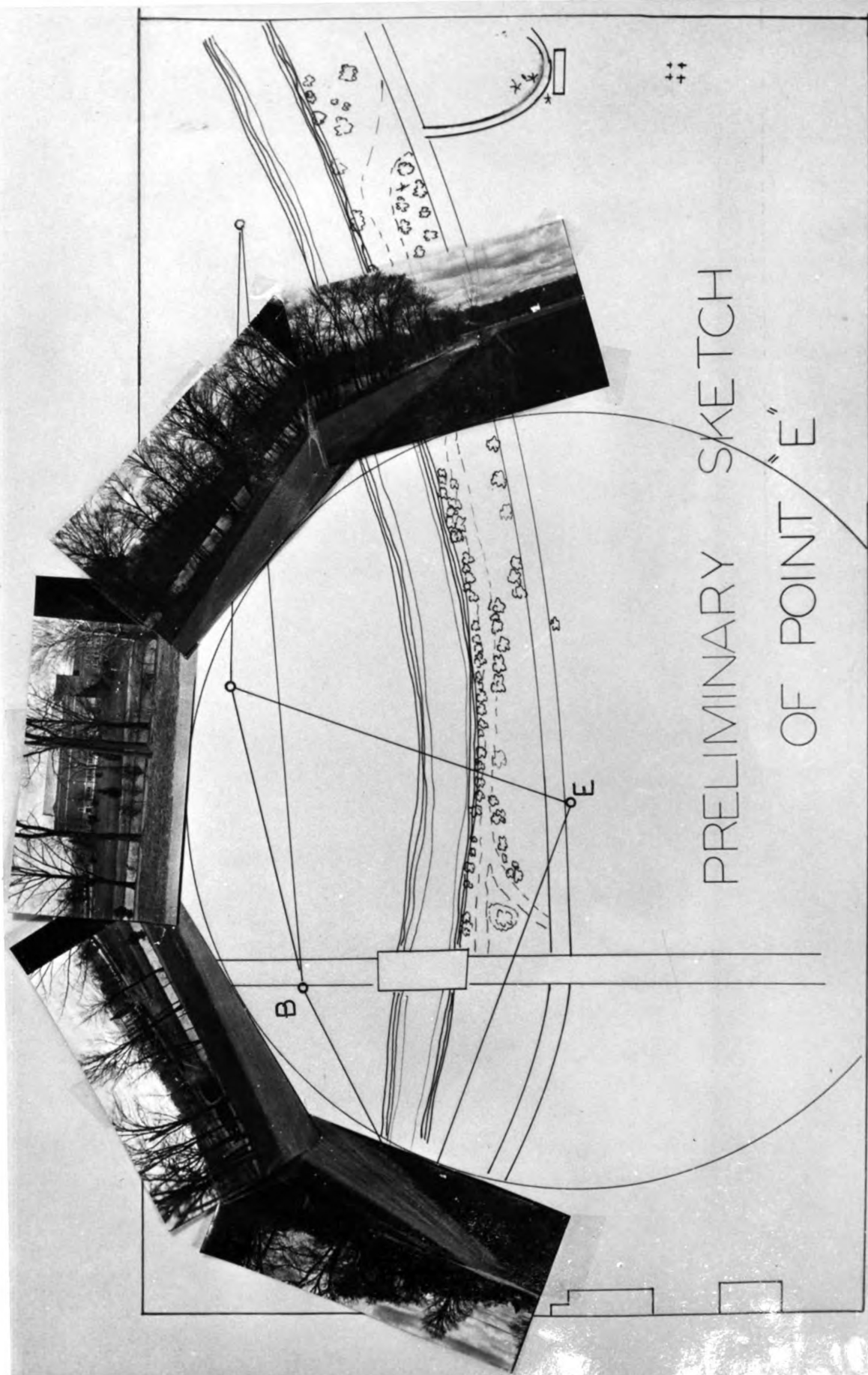
A G

PORTION
OF
M S C CAMPUS
SIT STADIA TRAVERSE

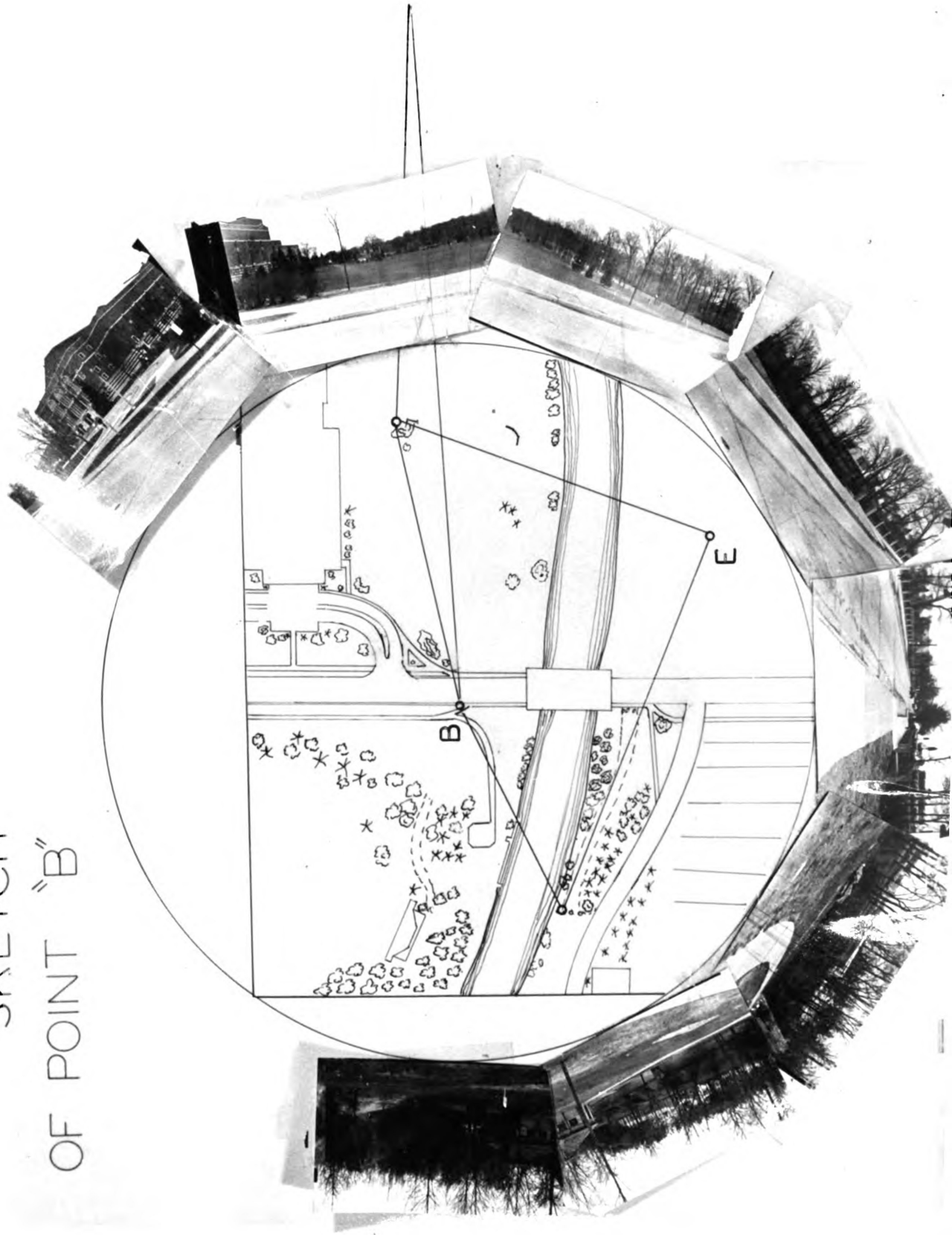


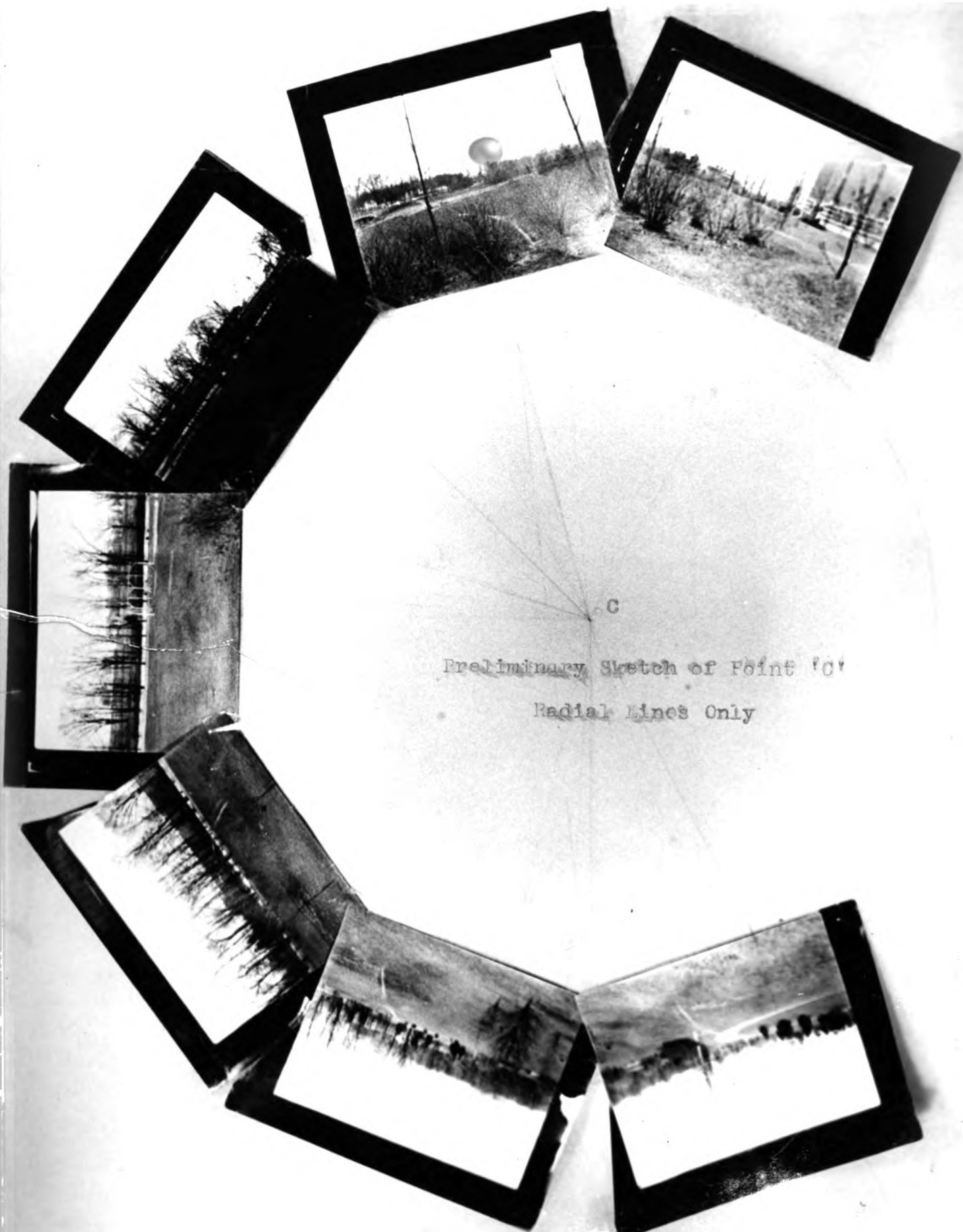
The following five pictures show the preliminary plotting at the various stations. Note that some of the preliminary sheets contain the topographical features while others contain only the radial lines necessary for the location of points by intersection.

PRELIMINARY SKETCH
OF POINT "E"

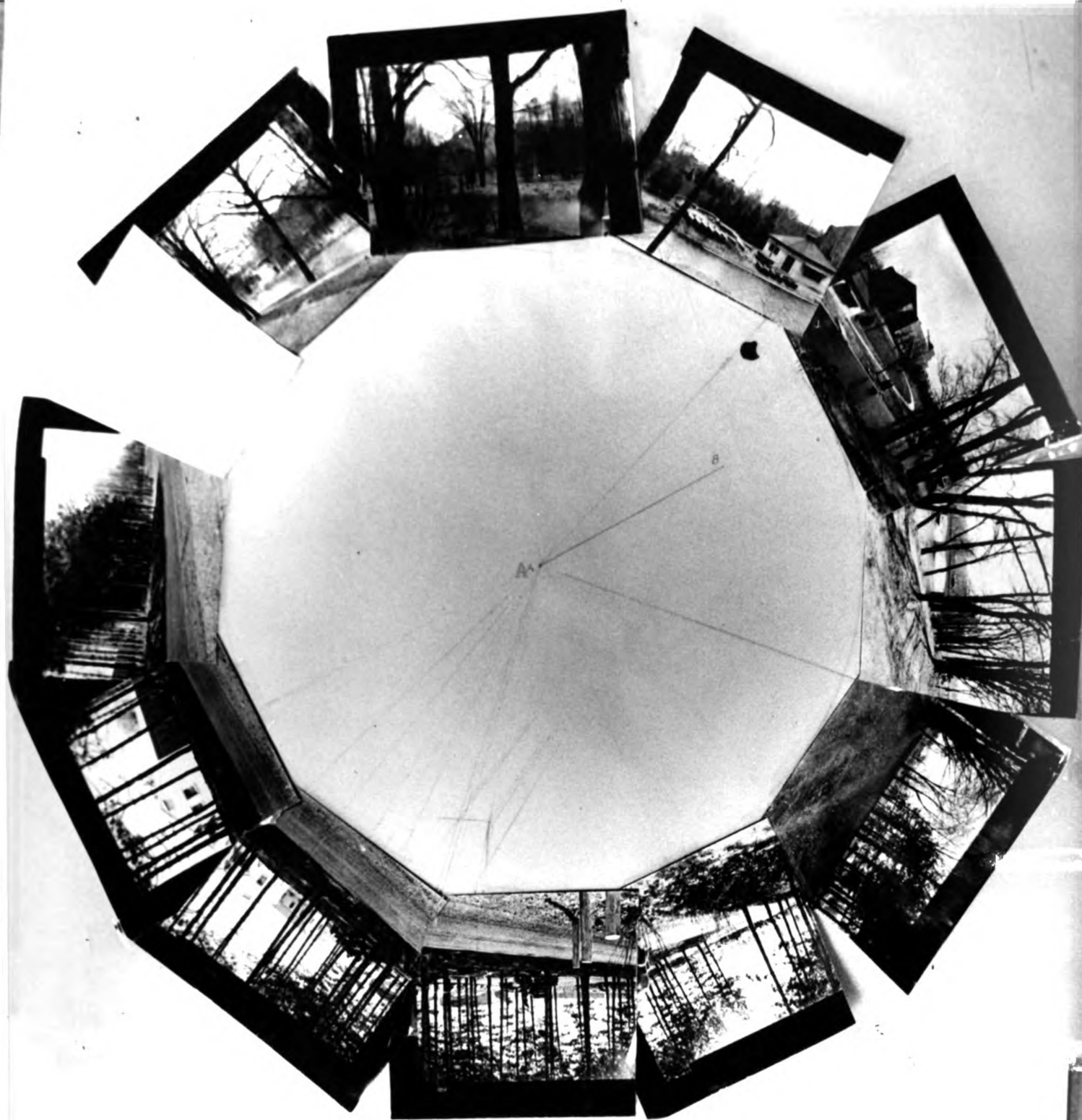


PRELIMINARY
SKETCH
OF POINT "B"



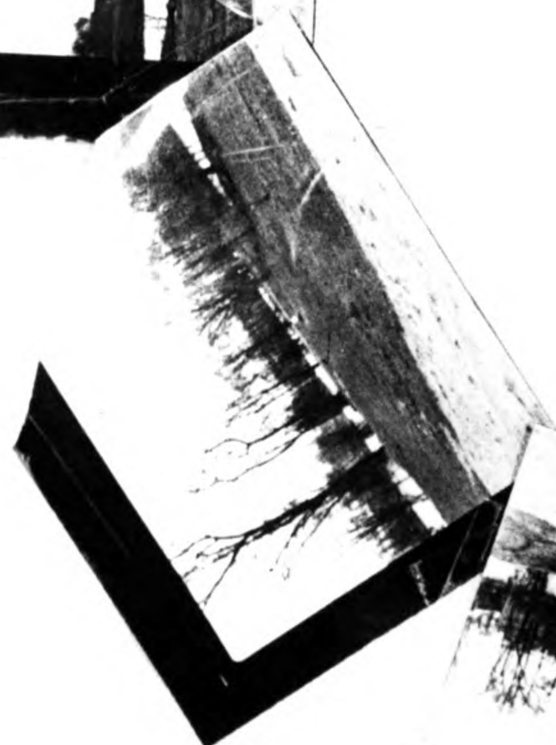


Preliminary Sketch of Point 'C'
Radial Lines Only



Preliminary Sketch of Point 'A'

Radial Lines Only



Preliminary Sketch of Point "D"

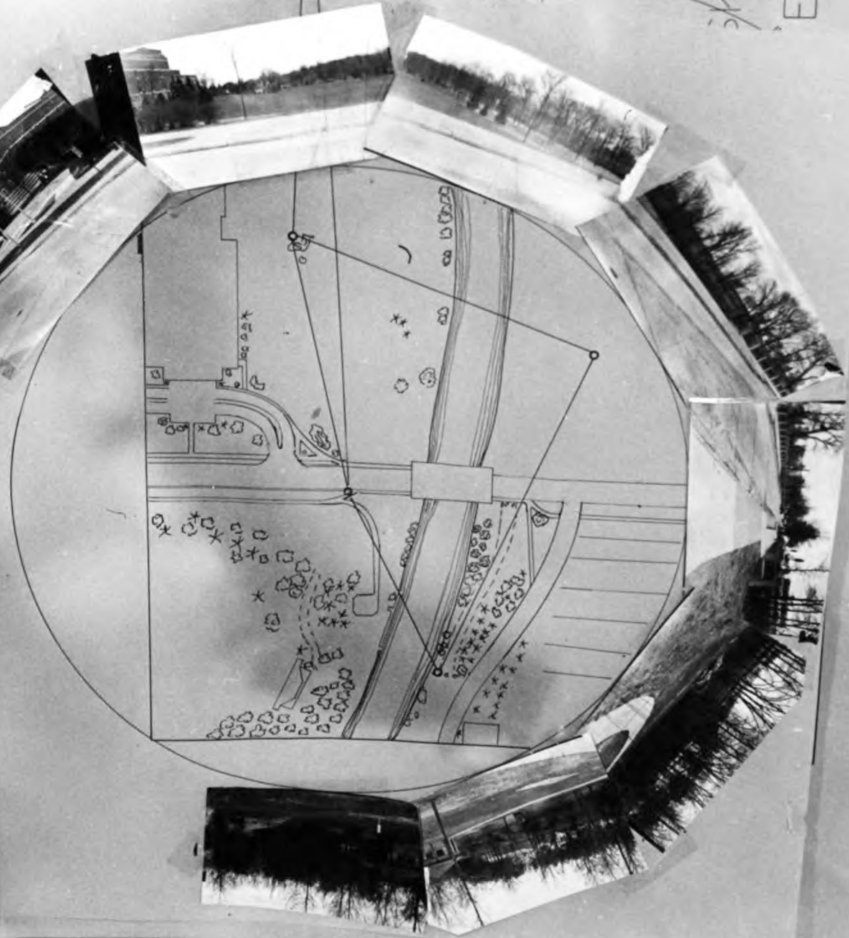
Radial Lines Only

On the following page, the method of compilation of the final map is shown. In the compilation, the preliminary sketches were placed one on top of the other and correctly oriented. To show this more clearly, note that "D" was offset slightly. (Lower portion center of the illustration)

SKI TIME

WILSON'S latest proposal
seems to be the best
one. It is the only one
that is not making the
ski area too small, and
it is the only one that
is not too expensive.
Page 16.5

PRELIMINARY
SKETCH
OF POINT "B"



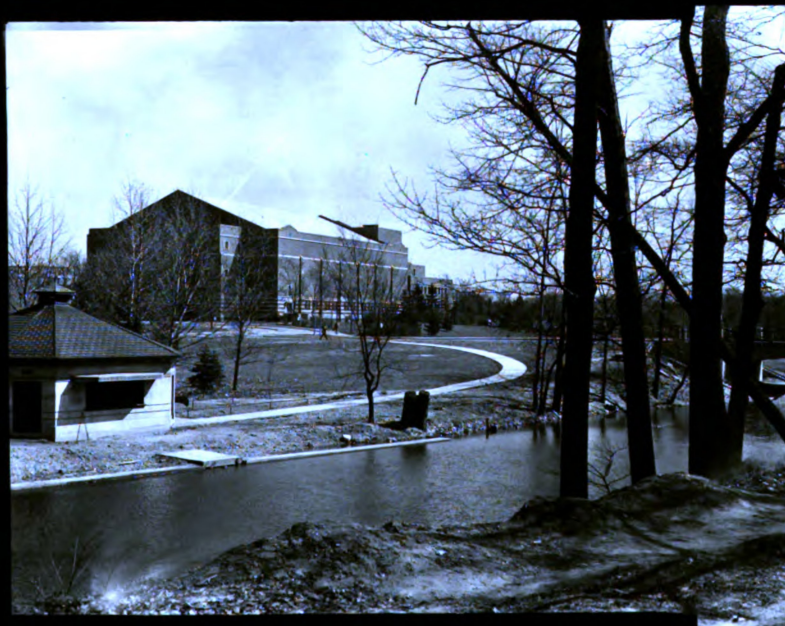
D
D

SKETCH
'E'

The following illustrations show the ease and difficulty with which various objects may be identified.



Point "B"



Point "A"

This is the Auditorium as viewed from points 'A' and 'B'. Note the ease in identifying the various corners, etc.



Point "B"



Point "A"

These are the same trees as viewed from points 'A' and 'B'. Note the extreme difficulty in identifying any one tree.



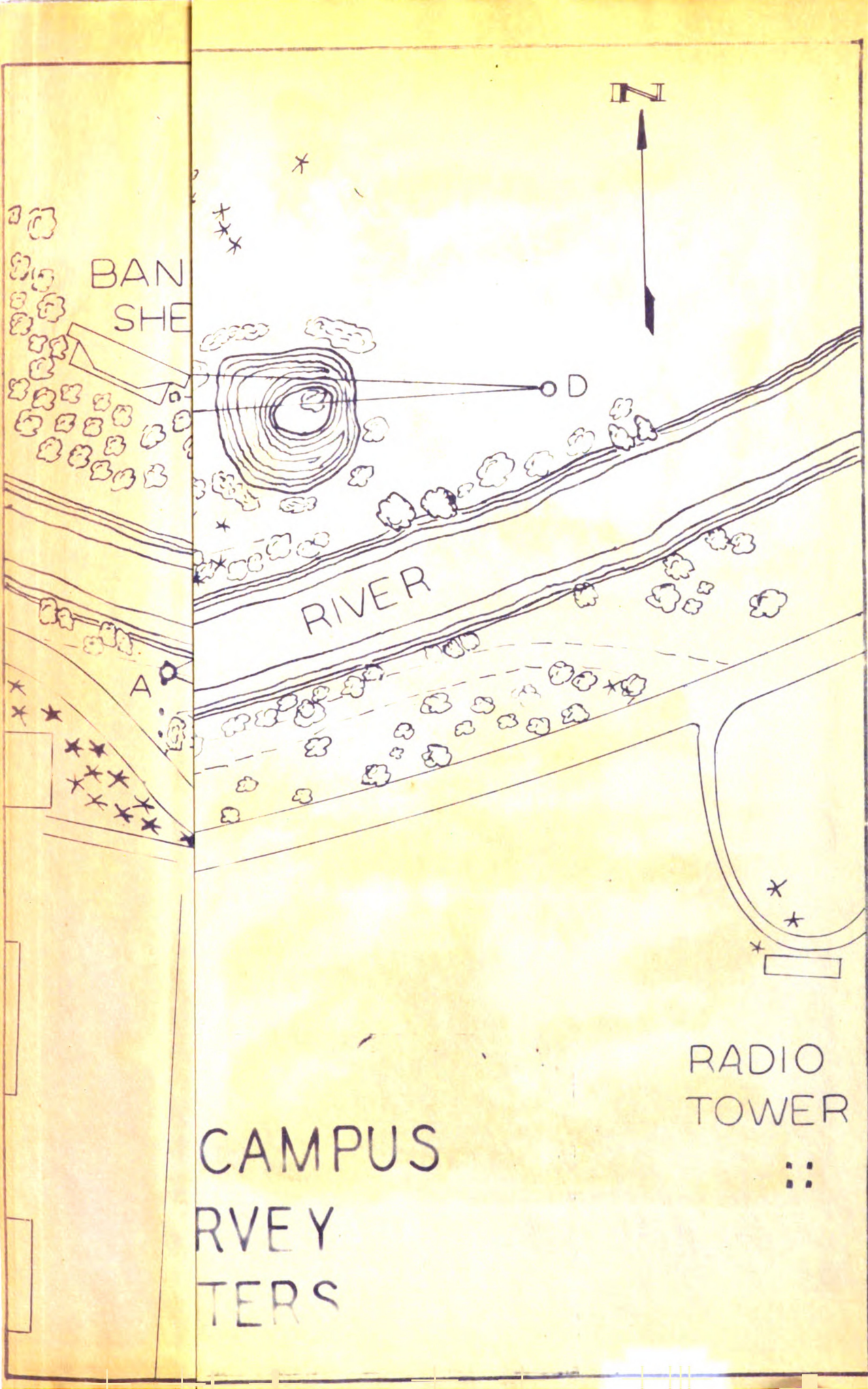
Point "E"



Point "C"

This is another example to show the extreme difficulty in identifying individual trees

from different points



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