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THE STUDY OF RELIEF MAP CONSTRUCTION

AND

THE CONSTRUCTION OF A RELIEF MAP OF THE MT. KATAHDIN AREA IN MAINE

A THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science (in Civil Engineering)

By

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B.S., University of Maine, 1932

College of Technology

Graduate Study

Orono, Maine

June, 1933

108926

PREFACE

The construction of a relief map of Mt. Katahdin was first suggested to me by Professor E. H. Sprague. The project was of special interest to me since I have spent much time in the Katahdin country during the past ten years.

Because of the lack of published material, much of the data was obtained through correspondence with those who have constructed relief maps. I am indebted greatly to Mr. Anton Zenns, of the Babson Institute, who gave me very scholarly and instructive aid on the methods of relief map construction. Honorable Percy C. Black and Mr. J. T. Rudderham of the Nova Scotia Relief Association, gave very definite accounts of the construction of the Nova Scotia relief map located at Amherst, Nova Scotia.

To Professors H. W. Leavitt and W. F. Scamman and Messrs. L. E. Day and E. W. Davee of the University of Maine, and to Mr. Roy Dudley, an experienced guide from the section covered by the relief map, and my father, Mr. R. P. Robbins, I owe considerable thanks for assistance; Professor E. H. Sprague has followed each step in the construction with great interest, making at times valuable suggestions. It has been the contact with the Civil Engineering Faculty that has made the construction of this project a pleasant and highly instructive task.

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INTRODUCTION

Relief maps are being developed in various parts of the country for the purpose of showing the outstanding features of certain areas. Notable among these maps are those to be found at the Babson Institute, Wellesley Hills, Massachusetts; in the New York State Educational Building, Albany, New York; and at Amherst, Nova Scotia. The relief map at the Babson Institute,¹ which is in the course of construction, is of the continent of North America and is to be approximately 40 feet by 60 feet. This map is being built for educational purposes and will cost, when completed, half a million dollars. The map of New York State at the New York Educational Building is approximately 30 feet by 40 feet, and was built for both educational and publicity purposes. The map at Amherst, Nova Scotia, is a map of Nova Scotia,² 150 feet by 60 feet, and was built for publicity purposes only.

The desirability of a relief map for publicity purposes of the State of Maine, which is often termed the "play ground of the nation", can not be questioned. In fact, its desirability has been voiced by

1. See Appendix A for photograph of the map at Babson Institute.

2. See Appendix B for photographic reproductions of the map at Nova Scotia.

the Maine Development Commission.

The project of the construction of a relief map of the Mt. Katahdin area is a step toward the construction of a relief map of the State, by serving to create added interest in such a project and to solve some of the technical problems. The Mt. Katahdin area was chosen for this project because topographical data was available for building a relief map of Maine's most prominent topographic feature and because of the familiarity of the writer with this section.

The relief maps mentioned as either having been constructed or in the course of construction are all built to different scales, but all show physical features, such as mountains, lakes, and rivers. In the case of the New York and Nova Scotia maps, railroads and highways systems, combined with the location of the towns and cities, are found in addition to the physical features.

One of three methods of construction was used for each of these relief maps. The three methods are as follows: the cross-section and peg method, the cross-section and lamination method, and the built-up contour method.

The cross-section and peg method is adapted to the reproduction of large scaled reliefs, such as are being used in the study of hydraulic developments. This method is now being used in the study of the Mississippi Flood Control.

This method consists of cross-sectioning the base map into a fine square grid, care being taken to number and to letter the grid as an aid

in locating points.³ The elevation of each intersection is determined and recorded. The area to be built in relief is also cross-sectioned to any desired scale, thus allowing the resulting map to be enlarged or reduced. Pegs are driven at the intersections of the grid on the relief area. The elevation of these pegs is determined by applying the scale of the relief area to the elevations found from the intersection of the base map. When all the pegs are driven to the proper elevation at the intersection, the area is ready to be filled. This filling, or grading in, may be accomplished with plaster of Paris, cement, sawdust and cement, or any other substance that may be desired. The variation between the pegs is taken to be a straight line variation, so that when the relief area is complete the surface will be a great number of small planes tipping in many different directions.

The cross-section and lamination method has also been used to a large extent in the production of models for hydraulic study. By the proper adjustment of the cross-sectioning of the base map and the relief area, any desired degree of enlargement and accuracy may be obtained.

This method consists of cross-sectioning the base map, using fine intervals along one dimension, which is the same as the center line of

3. See Appendix C for blueprint showing details of construction.

each lamination.⁴ The intersection of these fine intervals with the larger intervals along the other dimension determine the points at which the elevation will be taken. Lines are drawn on the laminations, to some scale corresponding to the larger intervals on the base map. The elevations of the intersections are laid off on these lines, and these points are connected with straight lines, each lamination being cut out along this elevation line. A lamination is made for each of the fine intervals drawn on the base map. These laminations are placed side by side and nailed in place. In many cases, the breaks that occur from lamination to lamination are filled in, the variation being taken as a straight line. For field work, and some hydraulic study, however, this is not always necessary.

The built-up contour method is adapted to the production of small or large accurate models of various topographic features. This method has been used for most of the accurate models; for instance, the relief map of North America at the Babson Institute, Wellesley Hills, Massachusetts, was built, with some variation, by this method.

This method consists of enlarging or reducing the base map by means of photograph or pantograph. When the base map has been reproduced to the desired size of the relief map, the enlarged map, if too large to be handled easily, may be cut into sections. Each of these sections are backed with carbon-paper.

4. See Appendix D for blueprint showing details of construction.

Some thickness of material is chosen to represent the contour interval of the map. For accurate work this contour interval will be 20 feet or, in very mountainous country, 50 feet. The material is cut to the size of the sections. A sheet of the material is placed in a close fitting frame with the carbon-backed section upon it and two successive contour lines traced upon the material, the order of tracing being from the lowest elevation to the highest. Care is taken to mark the elevation of each trace. This method is repeated for each contour line upon the section.

Each sheet of material is cut out along the lowest contour line on the sheet. The trace of the higher contour is placed on the lower contour cut-out, to aid in orienting each of the succeeding contour layers. A sheet of material is cut for each of the contour lines appearing on the map section.⁵

When all the contour sheets had been cut out, the relief map is made by placing the contour cut-outs one on top of the other and nailing them in place, each contour cut-out being oriented by its traced outline upon the contour sheet below. When the sheets have all been nailed, the steps that occur from contour to contour may be graded in to give a smooth rolling surface (See Appendix E).

5. See Appendix E for blueprint showing details of construction.

The method which was used in the building of the relief map of Mt. Katahdin is a modification of the built-up contour method. The reason for this selection is that this method seems to give the most accurate results and the best means of control. In addition, this method allows a great number of maps to be produced from the same negative, making this method adaptable to commercial production of relief maps.

This method is discussed under the following headings:

Adaptation of Topographic Material

Building Negative Forms

Casting Positive Blocks

Smoothing Contour Steps

Decorating of Map

ADAPTATION OF TOPOGRAPHIC MATERIAL

The basic information used to build this relief map was obtained from the United States Geological Survey reconnaissance sheet of the Mt. Katahdin area, which was surveyed in 1927. The area lies between the North Latitudes $45^{\circ} 50'$ and 46° and West Longitudes $68^{\circ} 50'$ and $69^{\circ} 00'$, an area of approximately 108 square miles. The reconnaissance map was used for this purpose as it is plotted to a larger scale than the finished sheet, and as on it only the topographic features are shown.

In order to bring out sufficiently the topographic details for use as a working basis upon which to build the relief map, it seemed necessary to enlarge the reconnaissance map at least four times. The

first step in this enlargement was to divide the reconnaissance sheet into six equal parts and to glue each part to a sheet of type-writer paper. In the center of one of the parts a 2-inch circle was drawn (See Fig.1). This served as an indicator in the photo enlargement. That is, when the 2-inch circle on the map showed as a 4-inch circle on the ground glass of the camera, the map had been enlarged twice. An enlarged negative plate of each

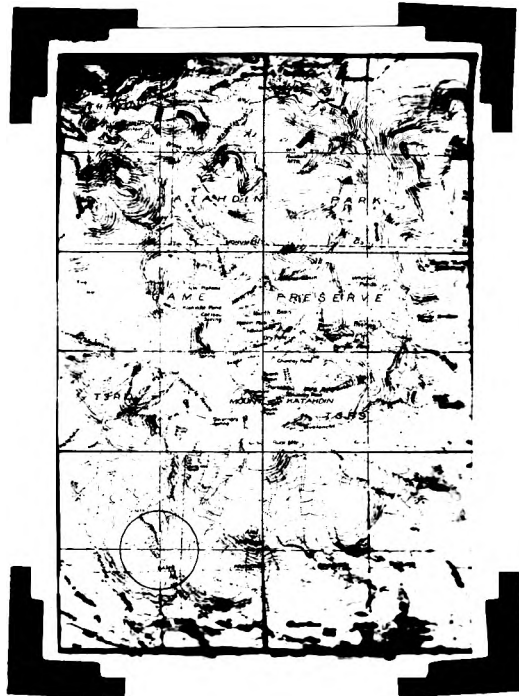


Fig. 1

of the six parts was made. From the negative plates, positive sections of the map were produced on Van Dyke paper. When these six enlarged sheets were assembled, the resulting map was twice the size of the original.

Each of these six enlarged sections was in turn to serve as a basis for further enlargement. This was accomplished by the use of the pantograph. That is, one of these enlarged sections was tacked to the bench and the pantograph set to step-up the photographic enlargement twice.(See Fig. 2). This pantographic enlargement was traced by the pantograph upon brown drawing paper. When this operation

had been completed, the map produced was four times the size of the original reconnaissance sheet.

The six enlarged sheets were assembled, and the resulting map measured as a check on the enlargement, care being taken to make the contours



Fig. 2

check from sheet to sheet while assembling the sections. The relief map was built to the same horizontal scale as these six enlarged sections, which were 20.5 inches by 19.7 inches in size. It was decided for purposes of economy and ease of handling to divide each of the six sections into quarters, thus making the relief map of twenty-four (24) blocks, each 10.25 inches by 9.85 inches.

BUILDING NEGATIVE FORMS

The negative forms were made by sawing out each 20-foot contour from a separate piece of cardboard and nailing these contour sheets one on top of the other, beginning at the highest point and building up to the lowest point. The material used for the negative forms was a pulp-board with a thickness of .063-inch, each sheet representing a contour interval, a raise of 20-feet in elevation.

This thickness was adopted as it gave a vertical exaggeration of three to one. That is, the horizontal scale was 1035 to the inch, while the vertical scale was 345 feet to the inch. This exaggeration was necessary to bring out the topographic features. Had the map been built to true scale, there would have been hardly any difference in elevation in the low land, and the peaks would have all appeared to be about the same height.

Carbon paper was glued to the back of each of the 24 enlarged map sections. Then a piece of cardboard, the exact size of the section, was placed in a close fitting frame, and the carbon-backed section placed upon it. Each 20-foot contour line was traced individually by means of the attached carbon, on a separate sheet of cardboard, the order of tracing being from the highest to the lowest point of the section (See Fig. 3).

Each sheet of cardboard was then sawed along the contour line, the order of sawing being from the highest to the lowest point in each block. The part serving as the negative was piled in one place, and



Fig. 3

the part serving as the positive piled in another place. Each sheet of cardboard in the negative had to be turned over when it was piled to produce a true negative. This is clear from a study of Fig. 4. Care

was taken to mark both the positive and negative as to altitude, section of map, and whether positive⁶ or negative.

Care also was exercised when lakes were encountered, for these did not

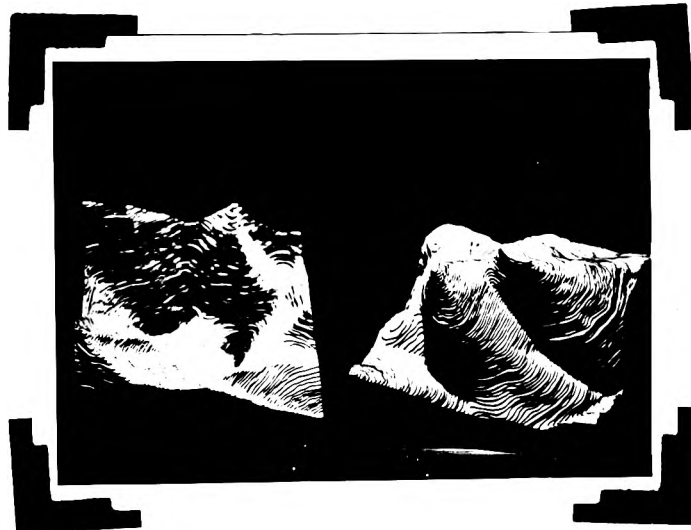


Fig. 4

always occur at 20-foot intervals. For example, in the case of a lake located at the elevation of 1330 feet, the lake was traced on both the 1340 contour and the 1320 contour sheet. The outline of the lake was cut out from the 1340 sheet, and the thickness of this section of cardboard, bounded by the lake outline, was carefully split. One of these split sections, bounded by the lake outline, the one used as a negative, was placed on the 1320 contour sheet as indicated by the traced outline of the lake; while the other part of the split lake

6. The positive of cardboard was nailed up to serve as a check on the work before the plaster casts were made.

section was replaced in the 1340 sheet cut-out. Thus the lakes on the negative were built up to elevation, while the lakes on the positive were depressed to elevation. The splitting of the thickness of the lake outlines was varied to correspond to the elevation of the lake. That is, a lake half way between the 20-foot contours would be split fairly in half, while a lake at an odd elevation, say 15 feet, would be split at three-fourths thickness. The one-fourth thickness serving to build up the lake on the negative section, and the three-fourths thickness being replaced in the positive sheet thus depressing the lake in the positive sheet.

The sawing operation having been completed and the parts properly piled, the next step in order was the nailing up of the negative blocks. Care was taken that these negative blocks had mutually perpendicular sides so that the casts from them would fit closely. To obtain these square negative blocks, a specially constructed box was used. The bottom of the box was the exact size of the cardboard, that is, 10.25 inches by 9.85 inches. The sides were carefully built at right angles to each other and strongly braced to prevent warping (See Fig. 5).

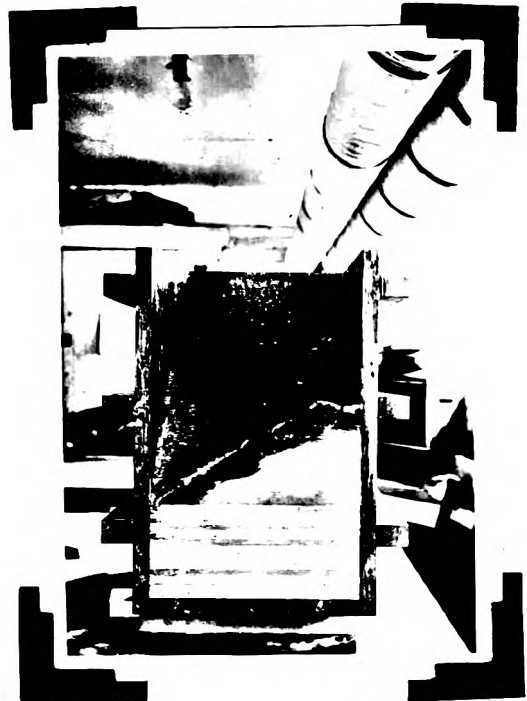


Fig. 5

The cardboards were placed in the bottom of the box, to the thickness of about one inch and nailed with No. 20 - $\frac{3}{4}$ inch wire brads. This inch bottom course of cardboard was taken out and turned over and nailed from the bottom also. When the bottom course of cardboards had been nailed from both top and bottom, it was replaced in the box the proper side up, and another layer of cardboards placed upon it to a depth of about one-half the length of the brads used. This layer was nailed and the operation repeated until the block was completed.

Most of the pieces could be oriented from one of the four corners of the box, but this was not true of all pieces. When such a group of pieces were encountered in tracing, each piece in the group was marked at the lowest elevation in the group, at a certain distance from some corner. When this group of pieces was encountered in nailing up each individual piece was oriented by drawing a perpendicular line at the proper distance from the proper corner and then placing the point marked on the sheet on this line and nailing it in place (See line AA in Fig. 6).

The next step in the preparation of the negative was that of

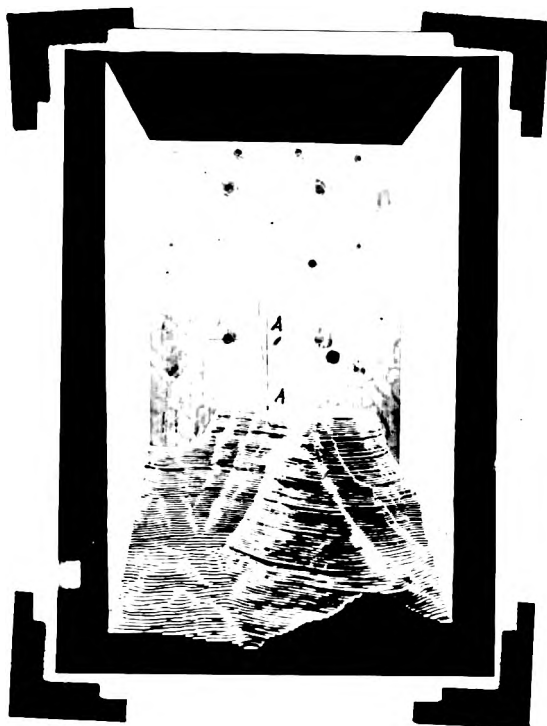


Fig. 6

shellacing and waxing to protect the cardboard from the water in the plaster of Paris. Each of the twenty-four blocks received three coats of shellac over the contour surface and on the edges. After this treatment, the blocks received a coat of hot paraffin over the contour surface and edges. Care was exercised in this step not to allow the wax to fill up some of the small peaks. As a further check against the water and to insure easy removal of the cast, the negative was coated with linseed oil just before the plaster of Paris was poured into the negative form.

CASTING POSITIVE BLOCKS

The highest point of the mountain and the bottom of the box was taken as the datum plane. That is, when the negative form of the highest peak was in the box ready to make the cast, the highest point rested on the bottom of the box. Therefore, when other negative forms of a lower altitude were placed in the box they were referred to this datum. To give an example, Baxter Peak, according to the key sheet,⁷ is 5260 feet high, South Turner Mountain is 3100 feet high. The difference in elevation is 2160 feet. Therefore, the box in which the positive casts are poured, must be padded up from 5260 feet to 3100 feet. The padding was accomplished by the use of left over cardboard, each sheet representing a 20-foot raise in elevation. Therefore, to pad from 5260 feet to 3100 feet required

7. See Appendix F, for key sheet giving the high point of each block and the amount of padding necessary.

108 sheets of cardboard (See Fig. 5).

The box used for the pouring of the casts was the same one as used to nail up the negatives. However, after the proper amount of plaster had been placed in the box, the fourth side was carefully screwed in place. This box was shellacked and waxed as were the negative forms, to prevent any change in size due to water and heat from the plaster of Paris mix.

The positive casts were made of plaster of Paris, as has been previously mentioned. The proper amount of plaster of Paris was placed in a mixing pan to large size, and water was added. The entire mass was mixed with the hands, water being added until the mix was the consistency of heavy cream. The proper amount of plaster could only be estimated as each block required different amounts. When the proper consistency of the mix had been secured, it was carefully poured into the box containing the negative form. Care was taken to apply only a small amount of the mix at a time so that the air bubbles could be removed. These air bubbles were removed by rocking the box constantly while the mix was being applied. This operation required the aid of a helper to insure a good cast. The box was filled to the top, and the excess struck off with a straight edge. The plaster was allowed a few minutes to set, then the bottom of the block was carefully smoothed off with a straight edge until the bottom was perfectly flat between both sides of the top of the box.

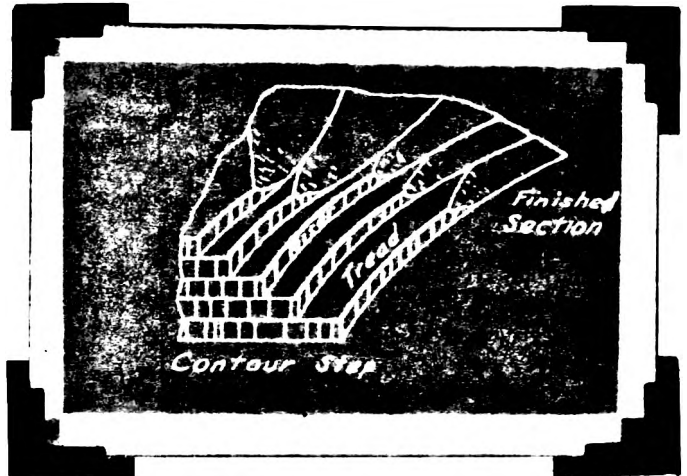
After the bottom of the cast had been properly smoothed, the

cast was allowed to remain in the box for an hour. At the end of this time the side of the box was removed, and the cast turned so that it rested on its bottom. The box was then removed, and set aside. The padding, if any was used, was taken from the top of the negative form, and replaced in the box. The negative form was removed from the positive cast by loosening it carefully around the edge, and gradually working to the center. When the negative form was loose, it was carefully lifted straight up, in order to prevent breaking any of the peaks.

When the negative had been removed, the positive cast was set in place in the map, while the negative was stored for future use. This process was repeated for each of the twenty-four blocks.

SMOOTHING UP THE CONTOUR STEPS

As soon as the casts had cooled, they were washed with alcohol to remove any oil that remained on the surface. Following this each positive block received a coat of orange water color. This was to aid in the cutting down of the contour steps. That is, the true grade occurred at the intersection of the bottom of the riser with the tread



(See Fig. 7). The steps were

Fig. 7

cut off until only a fine line remained at this intersection, thus making a smooth, continuous surface with fine lines upon it.

The cutting down of these contour steps was accomplished by the use of several small knives. Each knife having a different shaped blade. The reason for using knives and doing the work by hand was due to the very broken type of country, it being next to impossible to get into some of the valleys with any but hand tools.

The steps were all cut down until the surface of the hills and valleys were smooth and only showed faint lines where the steps had been (See Fig. 7).

After each of the twenty-four blocks had been smoothed of their contour steps, the blocks were assembled to form the map. Any small errors that

occurred in the elevation of the blocks were adjusted at this time. When the elevations had all been made to check, the joints between the blocks were carefully made to meet and fit (See Fig. 8).

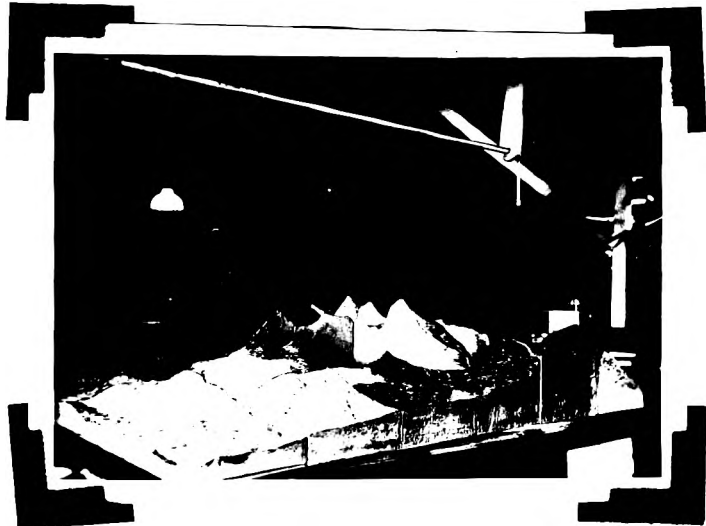


Fig. 8

When the map had been made to check in the matter of elevation at the joints, it was

assembled on a specially built base. The joints that occurred between the twenty-four blocks after the map was finally assembled were filled full of thin plaster of Paris, thus giving the relief map a continuous surface. The joints along the side of the map were also filled with plaster of Paris, so that the map appeared to be a monolithic piece. After the plaster had set, the joints were smoothed up with a knife, and the map was ready to decorate.

DECORATING THE MAP

The map was decorated by painting the map the color of woods, water, and barren rock at places where these different features occurred. Green was used for timber, light blue for water, and buff for the barren rock, while the trails were shown with white. All printing on the map was done with white ink. The paint used was white lead, the colors being obtained by mixing pigments with this white lead base.

The location of the lakes, streams, and trails were taken from the finished sheet of the United States Geological Survey. These details were picked off and transferred to the relief map by the use of a pair of proportional dividers. The woods and timber line was located by having Mr. LeRoy Dudley, a guide with thirty-five years experience on the mountain, come down from Chimney Pond and sketch the exact location of the line between the timber and the rock. In addition, Mr. Dudley was able to locate the seven new slides that occurred on the mountain last fall. The names of all the brooks,

streams, lakes, camps and all other points of interest were printed on the map. This information was partly taken from the government sheet and the rest came from Mr. Dudley's extensive knowledge of the section.

With the decoration complete, there remained only a few minor details to complete the project. The horizontal and vertical scales were placed on the moulding at the north and south ends of the map. The legend explaining the different symbols used was painted on the east and west sides of the map. The entire project, including the base, received one coat of white shellac.

See Appendix G, H and I for pictures of completed project.

CONCLUSION

A relief map of the State of Maine properly placed, would be an investment that would yield great returns to the State, provided the cost of such a map was not prohibitive. In making a relief map of the entire State, designed primarily for publicity purposes, it would be neither practical nor necessary to employ a method of such accuracy as that used in the construction of the relief map of Mt. Katahdin. The method used in the Mt. Katahdin area would be suited to the making of a map, showing the topographic features of such frequented areas as Bar Harbor, Mt. Katahdin and Moosehead Lake. The less traveled areas of the northern part of the State could well be built by the cross-section and peg method, and those areas needing a little more detailed and accurate construction could be built by the cross-section and lamination method.

The Maine Development Commission suggested a relief map of the State, 27 feet by 35 feet, constructed with topographic accuracy. The building of the relief map of the Mt. Katahdin area, which embraces approximately 108 square miles, required nearly one thousand (1,000) man-hours. Therefore the construction of a relief map of the entire State, (72,000 square miles, approx.) to such topographic accuracy, as above, would require the completed United States Geological Survey and several years of constant labor.

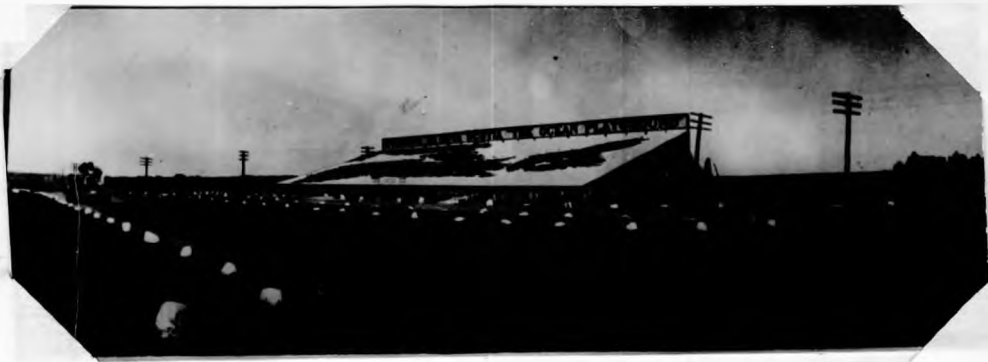
Such an expense does not seem warranted, when a less accurate map could be built to a much larger scale with far less expense, and with

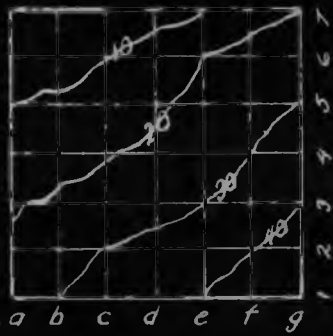
better emphasis on topographic features important from the point of view of publicity.

Appendix A

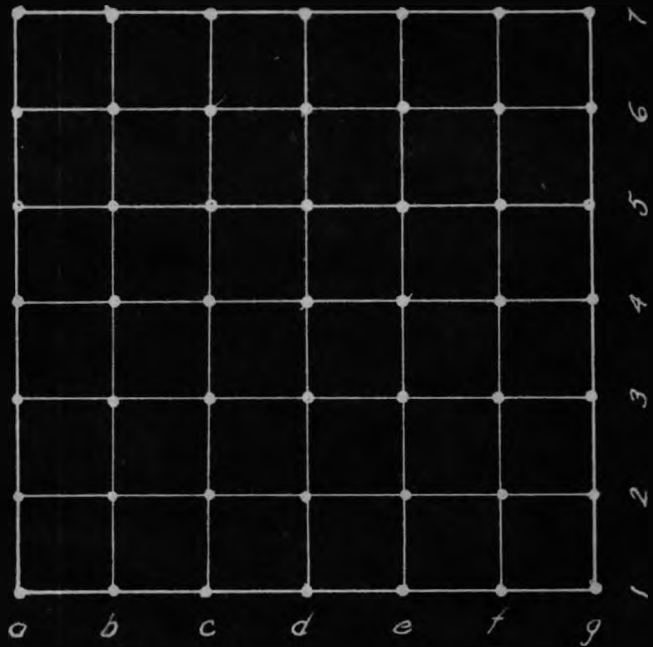
Photograph to be entered
here on arrival from Babson
Institute

Appendix B



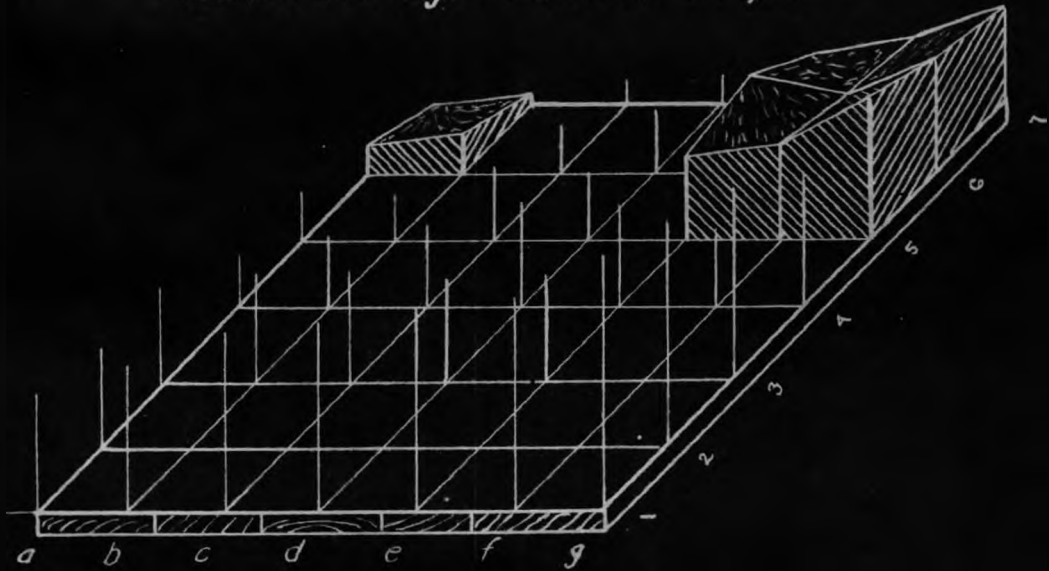


Base Map
Showing Cross Sec.



Plan of Relief Area

CROSS-SECTION AND PEG METHOD
of
Constructing Relief Maps



Sketch Showing Pegs and Filled Section

W.C. Robbins '32

W.C. Robbins '32

Appendix D

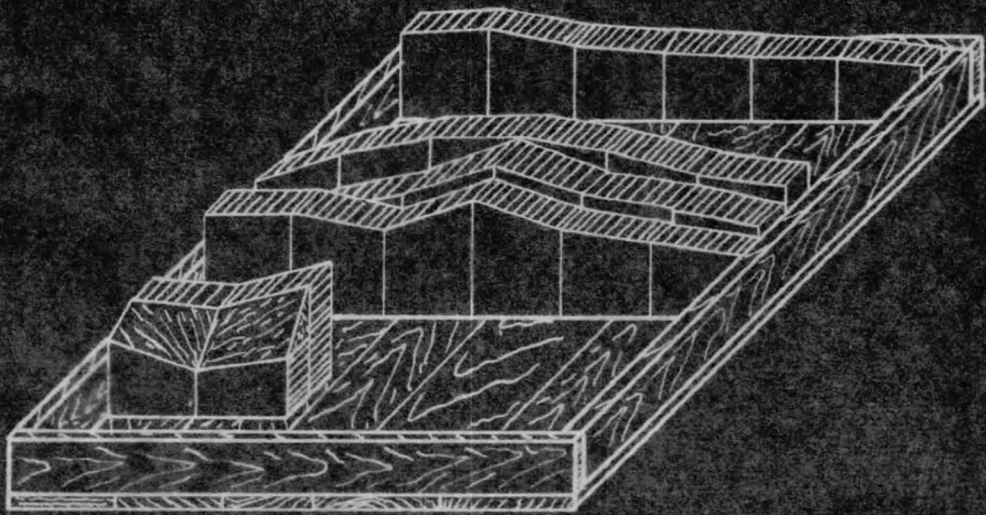


Base Map
Showing Cross-Section



S. Elevation Lamination No. 8

CROSS-SECTION AND LAMINATION METHOD of Constructing Relief Maps



Sketch Showing Laminations
and Filled Section

Appendix E

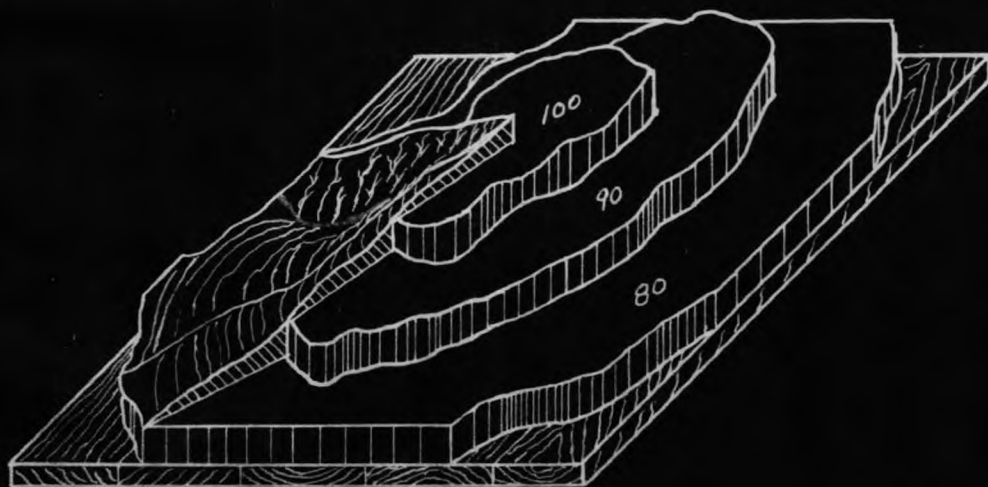


Base Map



Enlarged map showing method of orientation

BUILT UP CONTOUR METHOD



Sketch showing Contour Steps and Filled Section

Appendix F

KEY SHEET

Block A ₁ High 3460 Low 1860 Pod <u>90</u>	Block A ₂ High 2860 Low 1340 Pod <u>120</u>	Block A ₃ High 2800 Low 1180 Pod <u>123</u>	Block A ₄ High 3320 Low 1200 Pod <u>97</u>
Block B ₁ High 4140 Low 2260 Pod <u>56</u>	Block B ₂ High 4120 Low 1860 Pod <u>51</u>	Block B ₃ High 3900 Low 1380 Pod <u>68</u>	Block B ₄ High 3280 Low 1360 Pod <u>99</u>
Block C ₁ High 3700 Low 2620 Pod <u>78</u>	Block C ₂ High 4740 Low 2860 Pod <u>26</u>	Block C ₃ High 4420 Low 1620 Pod <u>42</u>	Block C ₄ High 3120 Low 1260 Pod <u>107</u>
Block D ₁ High 3740 Low 1140 Pod <u>76</u>	Block D ₂ High 5260 Low 2380 Pod <u>9</u>	Block D ₃ High 5200 Low 1920 Pod <u>3</u>	Block D ₄ High 2460 Low 1100 Pod <u>192</u>
Block E ₁ High 2220 Low 1020 Pod <u>152</u>	Block E ₂ High 3320 Low 1160 Pod <u>97</u>	Block E ₃ High 3360 Low 1200 Pod <u>95</u>	Block E ₄ High 2020 Low 780 Pod <u>152</u>
Block F ₁ High 1300 Low 580 Pod <u>198</u>	Block F ₂ High 1740 Low 580 Pod <u>176</u>	Block F ₃ High 1740 Low 600 Pod <u>176</u>	Block F ₄ High 1100 Low 580 Pod <u>208</u>

Appendix G



Appendix H



Appendix I

