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An Experimental Comparative Investigation of the Readability of a Flat Chalkboard and a Curved Chalkboard in a Classroom

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AN EXPERIMENTAL COMPARATIVE INVESTIGATION OF THE READABILITY OF A FLAT CHALKBOARD AND A CURVED CHALKBOARD IN A CLASSROOM

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by

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CHAPTER I

THE PROBLEM AND DEFINITION OF TERMS USED

The development of the blackboard has been slow in comparison with the progressive developments made in the design and construction of most other school equipment since the turn of the century. This paper contains the description of a new concept of chalkboard design. It also presents the results of two tests of this chalkboard: one conducted at James Blair High School in Williamsburg, Virginia, and the other conducted at Cradock High School in Portsmouth, Virginia.

I. THE PROBLEM

Statement of the Problem. This study was undertaken as a preliminary and exploratory investigation to determine (1) the relative effectiveness of a curved chalkboard as a visual aid, and (2) the particular type of curve which might lend itself to chalkboard use and merit more complete investigation in further intensive study.

There was no intention in this preliminary investigation to examine each possible type of curved surface and arrive at a concrete conclusion as to the most effective curve for chalkboard construction. The data derived from this study is intended merely as a land mark for further and intense investigation.

Importance of the Study. The chalkboard is the prime visual aid used in classrooms today. It is an integral part of almost every

classroom in the country. In fact, the various state departments of education virtually compel the schools under their jurisdiction to erect permanent chalkboards in every classroom. A minimum of 16 - 20 linear feet of chalkboard is recommended by most states, and in one state, North Dakota, 20 linear feet is required by law.[1] A flat chalkboard is normally found at the front of every classroom. The use of a flat chalkboard has resulted in the following complaints and chain reactions which have been noted as a result of the author's teaching experience and observations of fellow teachers.

(1) Instructors utilizing the chalkboard have experienced difficulty in reading that which has previously been written on an adjacent panel of the board. In order to review a long line of writing, the instructor must step back from the board until he gains sufficient angle to read the entire surface.

(2) Pupils seated in the classroom have complained that they are unable to read everything that is written on the chalkboard. Many pupils who are seated on the sides of the room, especially those near the front, have had to move in order to copy an assignment or read writing placed on the far end of the chalkboard.

(3) The inability of pupils seated at the sides of the classroom to read material placed on the board has resulted in the construction of long, rectangular classrooms in which the chalkboard is located at one of the short ends.

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[1] A list of recommendations of the several states is contained in Appendix A.

(4) The use of these long, rectangular classrooms has, in turn, caused instructors to assign seats to pupils. Thus, those students with good or excellent eyesight are assigned to the middle or rear portion of the classroom, while those with poor eyesight are placed at the front of the room. This arrangement tends to place the students in groups which remain relatively constant from classroom to classroom and year to year.

(5) This type of classroom is not conducive to effective teacher control over, and eye contact with the individual pupils. Furthermore, audibility in the rear of the room is less than at the front. The student at the rear of the classroom is seated behind a long row of fellow students—in a position divorced from the teacher by distance and classmates.

None of the above complaints can be considered as contributory to effective and efficient classrooms. This study represents an attempt to improve the existing classroom situations which are reflected in the detrimental aspects of linear chalkboards cited.

II. DEFINITIONS OF TERMS USED

Chalkboard: The use of a large writing surface at the front of a classroom has long been common. The term "blackboard" was naturally applied to the first "black" "boards" and slate boards which were affixed to the classroom walls. Recently, however, boards of composition material have come into prominence. The traditional black color has been replaced in many cases by pink, green, brown, and even white. Despite the changes of color, chalk has remained the universal writing material. Hence, the

term "chalkboard" has now been accepted as indicative of a large board-like surface upon which chalk is rubbed in order that a number of people may read a single bit of material at the same time. The term "chalkboard" and its contraction "board" are used interchangeably in this paper.

Angle of Vision: This is a term which is used herein to refer to the angle formed at a point on the chalkboard by the line-of-sight of a student and the tangent to the chalkboard at that point.

Viewing Point: The point on the floor of a classroom from which an entire chalkboard or any portion thereof may be viewed has been referred to in this paper as a "viewing point". More particularly, the point in space directly above the point on the floor and at eye level of a seated student is the specific location of a "viewing point". For the sake of simplicity this has been referred to as a point on the classroom floor.

Reflectance: Most of the available literature concerning chalkboards makes reference to the "reflectance" of a chalkboard. This is a relative term which designates the percentage of incident light which is deflected from a given board. Thus a chalkboard having a reflectance of ten per cent would be one which reflects ten per cent of the light which strikes it and absorbs the remaining 90 per cent.

Chalkboard Revisibility: This is a term which has been coined for the purpose of this report. It is used in reference to the area of a chalkboard that may first be read after an area of indistinguishable writing has been passed. If, for example, a chalkboard were viewed from

a position to the side of the board, the near side of the board might easily be read but writing on the middle portion might not be read. Any easily read portion of the board beyond this non-readable area would be referred to as a "revisible" portion of the board.

Readability and Distinguishability: These are terms which must be defined in relation to one another. Both are used in reference to the visibility of figures written upon the chalkboards. A figure was classified as "readable" if it could be correctly and quickly read from a given point within the classroom. From the same point, a figure was classified as "distinguishable" if it could be discerned as a separate and distinct figure but could not be further identified.

Total-Board-Viewing-Area: The portion of a classroom consisting of viewing points from which the entire surface of a chalkboard may be read is referred to as the "total-board-viewing-area". Its size is expressed in terms of the floor area in which the viewing points are located.

III. CHALKBOARD DEVELOPMENT

The Greeks and Romans were the first to use a tablet which might be classified as the original chalkboard. Inasmuch as this tablet was constructed of wax, it could be ironed out and reused. This concept was revolutionary and distinguishes it from the earlier and more permanent cuneiform writing.

The wax tablet was later replaced by individual tablets of slate. These were first introduced into this country in the late 18th century and became common in many schools. There is no available information, however, concerning the kinds of single, large "blackboards" used in America prior to 1820. "At that time", reports Paul F. Noca, noted school architect, "blackboards were used in our common schools for arithmetical calculations. In 1839, Connecticut reported that blackboards were common but not much used. Blackboards were introduced at West Point in 1817. Seven years later at Bowdoin College an instructor named Smyth used one with excellent results. In fact, the innovation proved such a sensation that he received his appointment as assistant professor of mathematics a year later."[2]

The early blackboards were constructed of wood or of a plaster-lampblack mixture. Soon, however, the quarries began to provide large slate slabs which could be mounted on walls. After 1850, slate blackboard received general acceptance, although surfaces of painted wood or glass in the traditional black were also used.

The traditional slate blackboard remains in use today but its popularity is largely limited to slate-producing areas. The slate boards are in the process of being replaced by composition chalkboards which offer uniform surfaces, lower costs, and a galaxy of colors. Of course,

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[2]Noca, Paul F., "Chalkboard and Its Future", American School and University, 1946.

black chalkboards are also manufactured; however, the demand is so slight that the largest chalkboard manufacturer in the country reported in 1952 that "Black chalkboards in new school construction, have almost disappeared since 1947. Production of black is so low that it can truly be analyzed as chalkboard for replacement only."[3]

IV. PREVIOUS CHALKBOARD INVESTIGATIONS

Several studies have been made in an attempt to determine the most effective chalkboard color and lighting. These studies have been concerned with classroom lighting, chalkboard colors and reflectance factors, height of chalk rails from the floor, and the degree of contrast between chalkboard and chalk. When manufacturers first introduced chalkboards of various pastel colors, school architects delighted in selecting the shade which would fit most esthetically the decorative color scheme of each new school. The selection was tempered by the long-standing belief that a chalkboard must provide a high degree of contrast with the chalk so that writing might easily be visible. In other words, "visibility" was considered something which could be determined in a fleeting glance. Therefore, chalkboards with a light reflectance of about ten per cent or less were selected so that a high contrast could be obtained with white chalk. Green boards were usually selected, but the particular shades were chosen by the architects so as to achieve a color balance with the rest of the

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[3] Chalkboard Remarks, Bulletin CR-2-52, (Chicago: Weber Costello Company, 1952).

room. Such arbitrary selection was somewhat refined by a recommendation made by Ray L. Hamon after some experiments to determine a combination of crayon and chalkboard that might give acceptable visibility on a high-brightness board. He concluded that "probably the optimum combination available at present is a chalk which is just off white on a light green chalkboard which has a light reflection factor of approximately 20 per cent."[4] Later, however, a monumental study of chalkboard visibility was made by Darrell Boyd Harmon.[5] His investigation is the only independent study which has been made on sustained vision of various types of chalkboards. With the assistance of four optometrists, a careful and prolonged investigation was conducted on dark chalkboards which recorded a reflectance of 10 per cent or lower and light chalkboards which recorded reflectances of 15 per cent or higher. It was concluded that:

a. The greatest visual <u>disadvantage</u> in sustained visually-centered tasks probably exists with chalkboards of "normal" contrast—that is, chalkboards on which a dark chalk or crayon is used on a light chalkboard;

   The chances are over 7 to 1 that white chalk on a dark chalkboard is more visually advantageous than dark chalk on a light chalkboard (such as black on white);

b. There is no particular visual advantage of dark green chalkboards over black chalkboards, when the reflectance or the contrast is practically the same;

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[4]Ray L. Hamon, <u>Lighting Classrooms</u>, United States Department of Education, Pamphlet No. 104 (Washington: Government Printing Office, 1948) p. 5.

[5]Darrell Boyd Harmon, <u>A Preliminary Study of the Relation of Sustained Visually Centered Activity and Certain Types of Chalkboards</u> (Austin: The Author, 1952).

c. The chances are over 15 to 1, that yellow chalk on a light green chalkboard is more visually advantageous than the high contrast of either white on black, or dark chalk on a light background.[6]

No further studies have been made since Harmon's investigation. Much of the literature published by national and state educational advisory groups makes reference to chalkboard reflectance; however, none of the recommendations have resulted from independent research.

As a result of the above discussion, it is concluded that a light green board with a reflectance of approximately 20 per cent and used in conjunction with yellow chalk provides the most advantageous chalkboard combination.

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[6] Harmon, op. cit., p. 9.

CHAPTER II

CHALKBOARD CONFIGURATION

I. BASIS OF CURVE SELECTION

Previous studies have established the desirability of light green composition boards on which a teacher writes with yellow chalk. Nevertheless, the writer has observed that many pupils within the classrooms still experience difficulty in reading that which has been placed on chalkboards. Accepting the results of previous research, it is this thesis that the number of chalkboard faults could be further reduced if the angles of vision at each point on the board were made as near ninety degrees as possible. In other words, this study was predicated on the belief that a concave chalkboard would substantially increase the angles of vision and thus alleviate the effects of small angles and large distances. It is believed that a curved chalkboard will yield larger angles of vision to those pupils seated at greater distances from a point on the board and yield small angles of vision to those seated at short distances from the same point.

II. SELECTION OF A CURVE

General: There are innumerable curves, or portions of curves, which would provide the basis for a concave chalkboard. However, additional conditions created by the practical necessity of complying to basic room design reduce the field of selection considerably. Since a concave

wall will reduce the square footage of available floor space in a normal, plane walled room, the curve which is elected must keep this loss to a minimum. In addition, a sizeable portion of the board must remain flat so that devices such as rulers and cut-outs may be used as effectively as on conventional chalkboards. This flatness should be at the center of the chalkboard.

Thus, the selected curve must form a concavity which is comparatively deep and virtually flat at the center portion. The curve which appeared best to suit the above conditions was the ellipse. The conical equation of this curve is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$. Figure 1, page 12, shows the ellipse in its general form. The length "a" is referred to as the semi-major axis. The length "b" is the semi-minor axis. As "b" becomes shorter and "a" remains constant, the ellipse flattens out—becoming long and narrow. By controlling the size of "a" and "b" the general ellipse can be shaped into a specific ellipse, the upper or lower half of which satisfies the general conditions for a curved chalkboard.

Selection of a Specific Curve. The selection of a specific ellipse to be used in the investigation was somewhat arbitrary. There seems to be no precedent to follow in the determination of the elliptical form. The selection, therefore, was made as a result of consideration of the known factors: (1) A minimum of lost space must result and (2) A large portion of the curve must be virtually flat. It was believed that the concavity should be deep enough to produce noticeable curvature over two-thirds the entire length, while producing a flat surface over the center third.

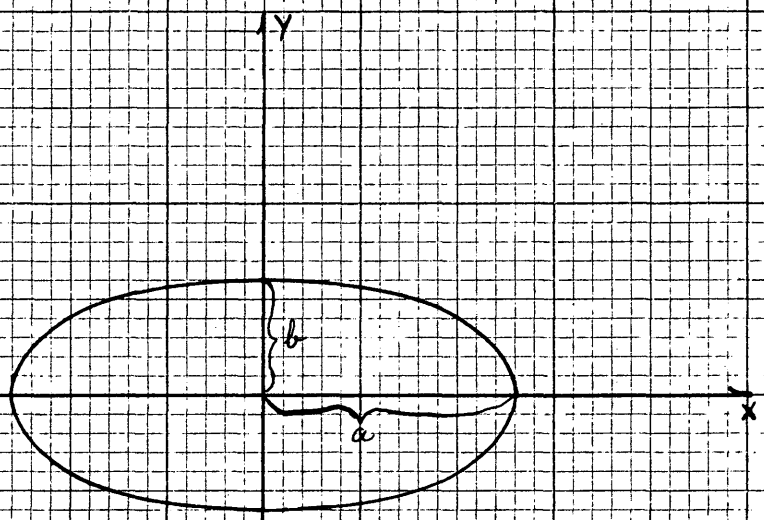

FIGURE 1

CONICAL FORM OF THE ELLIPSE

A survey of the State Departments of Education was conducted to determine the recommendations made by the States concerning chalkboards.[1] This revealed that those states which have written recommendations specify a minimum of 20 linear feet of chalkboard per classroom. This length was therefore selected as the value of "2a" in the specific ellipse so as to provide comparison with conventional boards of normal length.

The semi-minor axis was chosen as 2.5 feet because this provided considerable depth and yielded approximately six feet of nearly flat surface.

The equation of the selected curve is, therefore:

$$\frac{x^2}{(10)^2} + \frac{y^2}{(2.5)^2} = 1$$

or, upon simplification,

$$x^2 + 16y^2 = 100$$

The selection of this ellipse results in a net loss of 10.7 square feet of floor space in a classroom with a 20-foot frontage. This loss is computed by subtracting one-half the area of the ellipse from the area formed by a rectangle 20 feet long and 2.5 feet deep (50-39 . 27 = 10.7 square feet).

III. CONSTRUCTION OF THE PROTOTYPE

General. In order to compare the effectiveness of the proposed chalkboard with the conventional plane chalkboard, a full scale model was constructed. The board consisted of a large and elaborate frame to which masonite was fastened to provide a writing surface. Only one-half of the complete chalkboard was constructed: that is, one-quarter of the entire

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[1] Complete results of this survey are contained in Appendix A.

ellipse. The framework was constructed so as to allow the entire structure to be up-ended and reversed. Thus, this half-chalkboard could form either side of an entire elliptical board and therefore suffice for all comparative tests.

Specifications. The back support of the structure was 10 feet long; however, the actual chalkboard surface length amounted to 10.69 feet. Each base of the board was sufficiently large to keep the four-foot structure upright—no other means of support was built into the board. Thus, the support could be varied in accordance with the height of the conventional boards with which comparison was made. The board was constructed of two sections which were designed to be joined in the classroom. This made the board easy to transport to and from the test sites. The photographs in Appendix L show the chalkboard in its completed state. In addition, Appendix B contains specifications for the prototype board.

Comparison of Theoretical and Actual. Table I, page 76, shows the slight difference in measurements between the theoretical curve and that which was actually constructed. This difference is attributed to unskilled workmanship. The X values in Table I represent distances measured along the x-axis, and the y values indicate the distances of the curves from the x-axis. The symbol yt refers to theoretical positions and the symbol Ya refers to the constructed curve.

Surface. The chalkboard surface consisted of masonite screwed firmly to the framework. The screw holes were filled with plastic wood

and sanded. This completed surface was then given three coats of a special chalkboard paint manufactured by the Endur Paint Company of Salem, Massachusetts. This paint contained an abrasive which, together with the thick mixture, built up a rough surface of light green. After application of the final coat, the surface was lightly sanded with fine paper. The finished product may be seen in any of the photographs in Appendix L.

The entire process produced a surface which may be termed adequate, but by no means perfect. Some of the screw heads remained visible despite attempts to inset and cover them, and the juncture of the two sections was very noticeable when the board was completely assembled. Furthermore, the application and sanding of the paint was not held uniform and several "splotches" were visible on the chalkboard. Despite these defects, however, a test of the entire surface revealed a constant reflectance of approximately twenty-two per cent.

CHAPTER III

WILLIAMSBURG TEST PREPARATIONS

I. THE SITE

The first series of tests was conducted at James Blair High School in Williamsburg, Virginia. This is a new school which has only recently been completed. In fact, no classes have been held in the school and the chalkboards were unused. The classrooms incorporated modern concepts of pastel color schemes and fluorescent lighting. The room chosen as the test site contains two rows of double fluorescent lights and is finished in light cream and brown.[2] Figure 2, page 17, shows the over-all dimensions and arrangement of the room. This room was selected because it contained a chalkboard on the side wall which would permit lateral observations at a greater distance than would the front board. The chalkboard was of the hardwood fiber type--similar to the basic material contained in the curved board and the hue was practically the same in each.

The furniture in this room was removed with the exception of two tables. Four hardwood blocks were placed on these tables and the curved board was assembled and placed on top of the blocks. This raised the base of the portable board to a height (30 inches) equal to that of the permanent board.

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[2]The color scheme is shown in color photographs contained in Appendix EE.

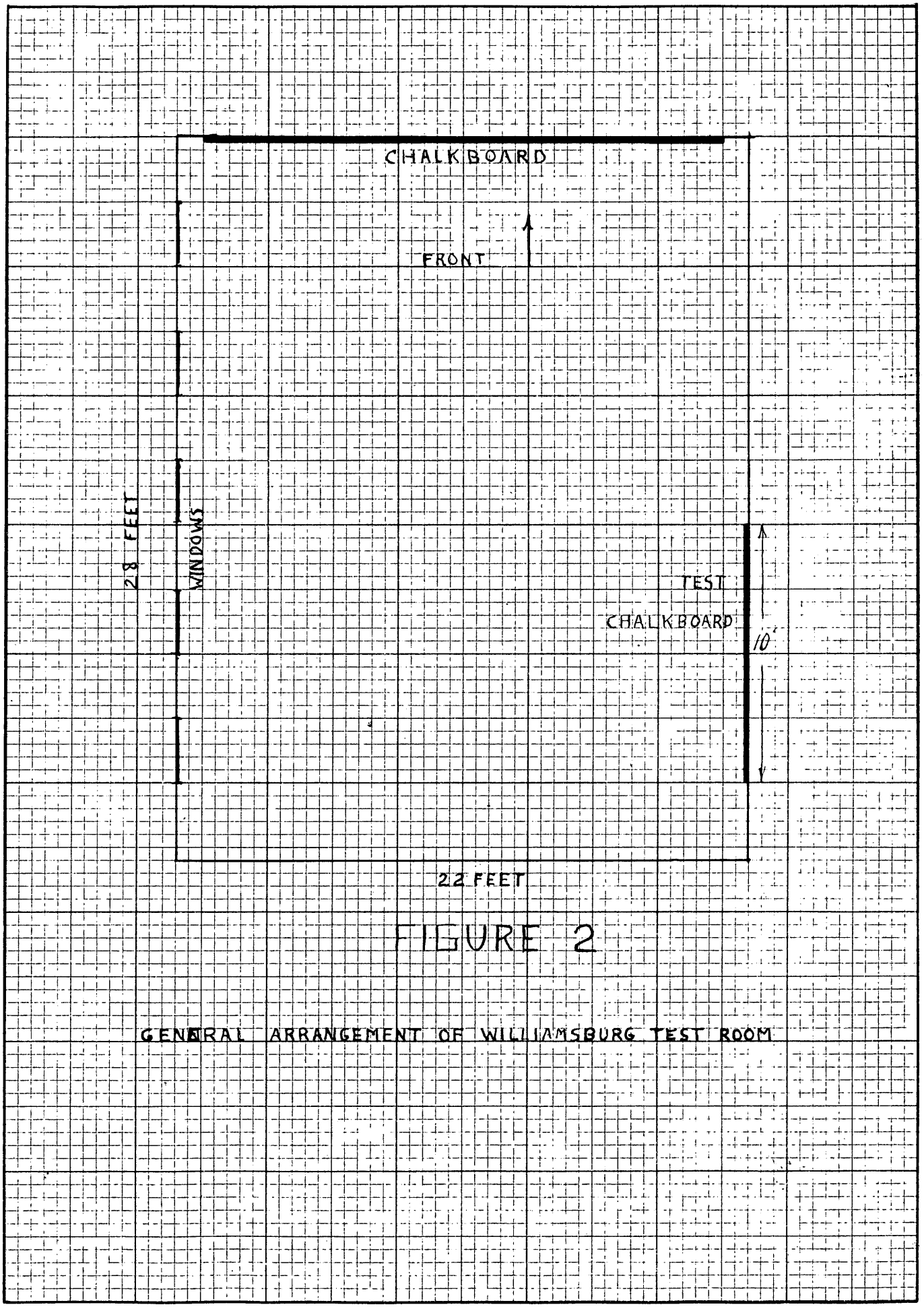

FIGURE 2

GENERAL ARRANGEMENT OF WILLIAMSBURG TEST ROOM

II. SUBJECTS

Adult subjects were chosen for the preliminary tests, because they possessed technical background and experience. In addition, these subjects were accustomed to classroom vision. Fourteen subjects were chosen for the tests including three mechanical engineers, one aeronautical engineer, one lawyer, one criminologist, a nurse, an architect, a mathematician, an advertiser, two teachers, and two housewives. Most of the subjects were approximately 24 years of age and all were in excellent health. A complete list of personal data may be found in Table II, page 77.

Each subject was given an eye examination by an optometrist before the tests commenced. All but one had 20x20 vision, or vision corrected to 20x20 by glasses.

III. PREPARATION OF TEST EQUIPMENT

Form on Boards. Both the flat and curved chalkboards were "chalked in" before any writing was placed on either board. This is a process recommended by chalkboard manufacturers in order to insure proper "breaking in". It required the placement of small amounts of chalkdust in the pores of the board to permit easy erasure; it was accomplished by rubbing the side of a chalk crayon over the entire surface and removing the excess dust with a clean eraser. The process was then repeated.

Groups of Symbols. Groups of nonsense syllables were printed across the center horizontal line of each board. These were comprised of printed letters and/or numbers. All these figures were seven-sixteenths

inch tall, three-eighths inch wide, two-eighths inch apart, and written in white chalk. Each group contained four figures and the groups were separated by a space of one and one-eighth inches. A total of thirty-four groups were placed on the flat board and thirty-five on the curved board.[3] A random selection of letters and numbers for use in the nonsense groups was obtained by means of a deck of playing cards. Each card of a deck which had been shuffled twenty times was turned up singly. In accordance with the assignments shown in Table III, page 79, the letter corresponding to the overturned card was written on a chart. The numbers were selected in a similar manner. The face cards and tens were removed from the deck and the procedure outlined above was repeated.[4] Groups of four figures were formed from the rows and columns of the two charts. The letters were utilized more than the numbers.

Both the curved and the flat chalkboards were covered with similar groups of figures. In other words, the first group on the near end of the flat board contained letters and numbers identical to those contained in the corresponding group on the curved board. The sequence of letters and numbers within the corresponding groups was changed in order to make memorization and recall difficult.

Parallel Sets. Six sets of vertical, parallel lines were also placed at corresponding locations on each type of board. These lines were twelve inches long and three-eighths inch apart. Three sets were drawn on

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[3]The board arrangement is shown in Appendix C.

[4]The charts of random numbers and letters are contained in Appendix D.

the upper half of each board, and three more sets were constructed on the lower halves. The number of lines contained in each set was varied.

At the top and bottom of each board, a line of circles containing broken arcs was constructed. The circles were of alternate size: the diameter of the larger circle was three inches while that of the smaller was one and one-half inches. Each circle contained one break in its arc. In the larger circle this break was one-fourth inch; in the smaller circle it was one-eighth inch.

Board Positions. Positions were marked on the floor of the test room so that the curved board could be moved quickly to specific locations. These board positions were selected to permit comparative tests from various viewing points within the room. The distances from a viewing position to the near point of each board and the angles of vision formed at these points were designed to be equivalent. Appendix E contains the exact positions of the board and the viewing points.

Subject Viewing Points. The viewing points were marked on the floor in grease pencil. These points were six in number and were arbitrarily selected at the side and end of the room. Appendix F shows the exact locations of these six viewing points.

Photographic Viewing Points. A total of thirty-one photographic viewing points were marked throughout the room.[5] These were selected so as to provide photographs of the flat and curved board from various angles and distances throughout the room.

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[5]Appendix F shows exact location of each photographic viewing point.

CHAPTER IV

WILLIAMSBURG TEST PROCEDURE

Before actual tests for record were begun, trial runs of the experiment were conducted utilizing seven different subjects. These trials enabled the procedure to be refined to the degree described below. The seven subjects in the trials had no contact with those who participated in the tests for record.

Orientation of Subjects. The tests for record were conducted during the evening hours of the 17th and 18th of August, 1955. Each night the subjects were first assembled in a teachers' lounge adjacent to the testing room. As a different group of seven subjects was used each night, two separate orientations were held. In each, the subjects received essentially the same information. They were first requested to fill out small personal data cards. While completing these forms, they were told that they were to be subjects in a test which would compare two types of chalkboard. They were generally informed as to the type of material that had been placed on each chalkboard and briefed as to the sequence of questions that were to be asked while they viewed the board. Finally, they were told that they would be asked to describe what they could see on a given board at the moment a question was asked. It was stressed that a statement of readability, not a studied guess, would be sought. They were requested to refrain from discussing the test or the chalkboards until the evening test period was completed.

Viewing Procedure. One subject at a time entered the testing room with his head turned away from the boards to be tested. A small stool seventeen inches high was located directly over one of the viewing points, and the subject was directed to this. The subject was then asked to turn toward the chalkboards and answer a series of questions about what could be seen. A question concerning the flat board was immediately followed by an identical question concerning the curved board. To answer these successive questions, the subjects pivoted on the stool and faced the board in question. The data thus obtained were recorded by two test assistants.

Attention was first directed to the center line of grouped letters and numbers on the flat board. The subject was asked to read the groups of random letters and numbers, starting with the nearest, until difficulty was experienced in distinguishing the separate figures. At this point he was asked to read the letters contained in each group. The first group in which only two of the four figures could be read correctly was recorded as the end point of chalkboard visibility. Immediately thereafter, the subject was asked whether any other portion of the center line could be read. He was then requested to start reading the groups at approximately the point he believed he could again begin to read. The first group in which three of the four figures were correctly read was recorded as the initial point of chalkboard revisibility. This entire process was repeated over the length of each board.

The subject was then requested to focus upon the upper row of circles on the flat board. He was asked to give the "o'clock" at which the break in each circle was located. That is, the subject gave the

position of the split arc which each of the circles contained by replying for example, "five o'clock". If the break could not readily be seen, the subject was asked to so state. This process was repeated for the upper line on the curved board and again for the lower lines on both boards. The results were recorded.

Finally, the subject was directed to examine the first two sets of vertical parallel lines on the flat board and count the number of lines in each. If the subject gave the correct answer it was so recorded; however, if the incorrect answer was given twice the set in question was recorded as "distinguishable". In the event that no answer was given (i. e., that the subject could merely see a single, solid line) the set was recorded as "indistinguishable". This procedure was then repeated for the first two sets on the curved board. All sets on each board were considered in like manner and the results recorded. At this point, the subject returned to the lounge, where magazines were provided, and another subject was brought into the test room. This procedure was continued until all of the seven subjects had viewed the boards from one position. Before the cycle of subjects was repeated at another viewing point, the number of parallel lines in each of the sets was altered. The rest of the material on the boards was left unchanged. All but two of the viewing points were located far to the side of the ten-foot fixed board. Points five and six were located at the end of the room and faced the front boards. For these positions, therefore, the right half of the front board was covered with material identical to that on the side board. The curved board was moved in front of the left half of the front board.

At the conclusion of each evening's test, the subjects were handed a five by eight card and requested to "write comments on anything which you have seen or undergone during the evening: anything or everything which comes to your mind". These statements were then collected and all test activities terminated for the evening.

The entire procedure which has been described above was repeated on the second evening.

Photographic Coverage. On the evening following the final test, several color photographs were taken in order to provide visual evidence of the comparative hues of the boards used. These pictures were taken with a 35 m.m. camera and flash bulbs. Black-and-white photographs were taken immediately thereafter with a 35 m.m. Bolsey B2 from the points indicated in Appendix F. These photographs were taken of first the flat board and second the curved board. For the second series of shots, the curved board was moved in front of the flat board and all pictures were retaken. The camera was placed atop a triped at a height of forty-seven inches, which was considered to be an average eye level of seated students. A standard photographic light meter was used to measure the foot-candles of light at each viewing point. The readings were recorded. The aperture and speed of the camera were not altered throughout the entire sequence of photographs. Only the focus was changed as the camera was moved from one position to another. Pictures of each type of chalkboard were taken from each viewing point, and at points directly in front and within ten feet of the boards, two or more shots were taken so as to cover the entire board.

The colored pictures were developed by the Kodak Laboratories, but the black-and-white pictures were developed and printed under special and rigid conditions. These latter negatives were processed with fresh chemicals and each remained in the developer the same length of time. They were printed on paper of identical grade and received identical exposures under the enlarger.

CHAPTER V

DATA RELATING TO THE WILLIAMSBURG TESTS

General. The chalkboards were examined from a total of six separate viewing points. Points one, two, and three were used during the first evening of test, while points one, four, five, and six were used during the second evening.[1] Since point number one was used for both evenings, the relative performance of the two groups of subjects can be compared. An analysis of the data contained in Appendix G reveals that the first group could read approximately fifty-six per cent of the letters and numbers on the flat board, while the second group read forty-four per cent of the same board. Inasmuch as the second group percentage included a zero recorded by subject 5b, the performance of the second group, as a whole, is considered approximately equal to that of the first group. Any exact group comparison is hindered by the following observations.

It was realized that chalkboard visibility is influenced by several variables. In this experiment an attempt was made to keep all but two of these variables constant. The distance of the viewing point from the near corner of the chalkboard and the angle of vision comprised these two exceptions. The success of the attempt to stabilize the remaining factors is difficult to determine. The contrast between the white chalk and the writing surfaces was, of course, virtually constant on all boards. The adhesiveness of the chalk to the boards was not specifically measured;

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[1] Exact locations of the six viewing points are shown in Appendix F.

however, no difference was apparent. The intensity with which the chalk was applied to each board was relatively constant, but all the chalk was not applied by the same individual and a slight variation in intensity may have resulted. Although the type of light, fluorescent, was constant, the degree of light and angle of incident light varied as the location of the curved board was changed. That is, the light upon the flat board remained constant while the degree and angle of light on the curved board varied slightly, depending upon the relative position of each spot on its surface to the light source. The style of writing was kept rigidly constant.

The vision of the subject is the final visibility factor and merits particular consideration. The eye test administered to the subjects by an optometrist revealed that all but one had 20x20 vision, or vision corrected to 20x20 by glasses. This classification is, however, a relative one, for there are many variations within this basic category. The optometrist was careful to point out that 20x20 vision is a very broad category within which large variations of vision are possible. Thus, the difference in amount of board visible to subjects at a particular viewing point is due largely to variation in the vision of the subjects.

I. CENTER LINE TEST

General. The results of the observations of the center line of grouped letters and numbers are contained in the graphs and charts in Appendixes G, H, and I.

Viewing Point Number One. An examination of the chart in Appendix G shows that from point number one roughly twice as much of the center line was readable on the curved board as on the plane board. Table IV, page 80, gives the percentage of the center line that was classified as "readable" and/or "distinguishable" by each of the fourteen subjects. Each subject who read less than fifty per cent of the flat board more than doubled his percentage in reading the curved board. When examined in this light, the data indicates that the effectiveness of the curved board was considerably greater than twice that of the flat board.

Viewing Point Number Two. This point was used during the first evening of tests and by only seven subjects. The results of these readings are found in the graph in Appendix H. It is apparent from this graph that the curved board had a slight advantage when the center line was viewed from point number two. However, the advantage was not as marked as that noted at the first viewing point. A comparison of percentages is made in Table V, page 81. Here, it can be seen that the amount of readable matter was approximately the same on each type of board (an average of 66.7 per cent on the curved, compared to 58.3 per cent on the flat board). The curved board does show decided advantage when the amount of distinguishable lettering is considered in conjunction with that which could be read.

Viewing Point Number Three. Once again, subjects in the first group were the only ones to compare the boards from point number three. This comparison may be seen in the chart in Appendix H. The curved board was considerably more readable from this point than was the flat board.

A glance at the chart reveals that three of the seven subjects were able to read the entire curved board while none of the subjects could read much more than half of the flat board. Table VI, page 82, contains the percentages of the center line which were visible to each subject. The subjects could read approximately twice as much of the center line of the curved board as the center line of the flat board.

Viewing Point Number Four. This point, as may be seen in Appendix H, was located at an extreme distance and angle from the near corner of each board. The angle of vision was sixteen degrees at the near end of the boards and fifteen feet from the viewing point. At this extreme position, most of the subjects were able to read only small portions of the center line. Five of the subjects could read none of the flat board, while the two remaining subjects could read only a small percentage of the writing. Although Table VII, page 83, shows that the percentages of discernible writing was greater for the curved board, both boards were extremely difficult to read.

Viewing Point Number Five.[2] This point was located at the rear of the classroom and used only by the second group of subjects. It was twenty-seven feet from the front wall of the room. From the data obtained at this point, the curved board made the center line more readable than

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[2]Together with point number six, twin viewing points were formed. The view of the curved board required from point five was actually taken at point six and vice versa, as may be seen in Figure 3, page This maneuver speeded the test procedure, because it eliminated many of the troublesome and time-consuming movements of the curved board. No adverse effects were created by this maneuver.

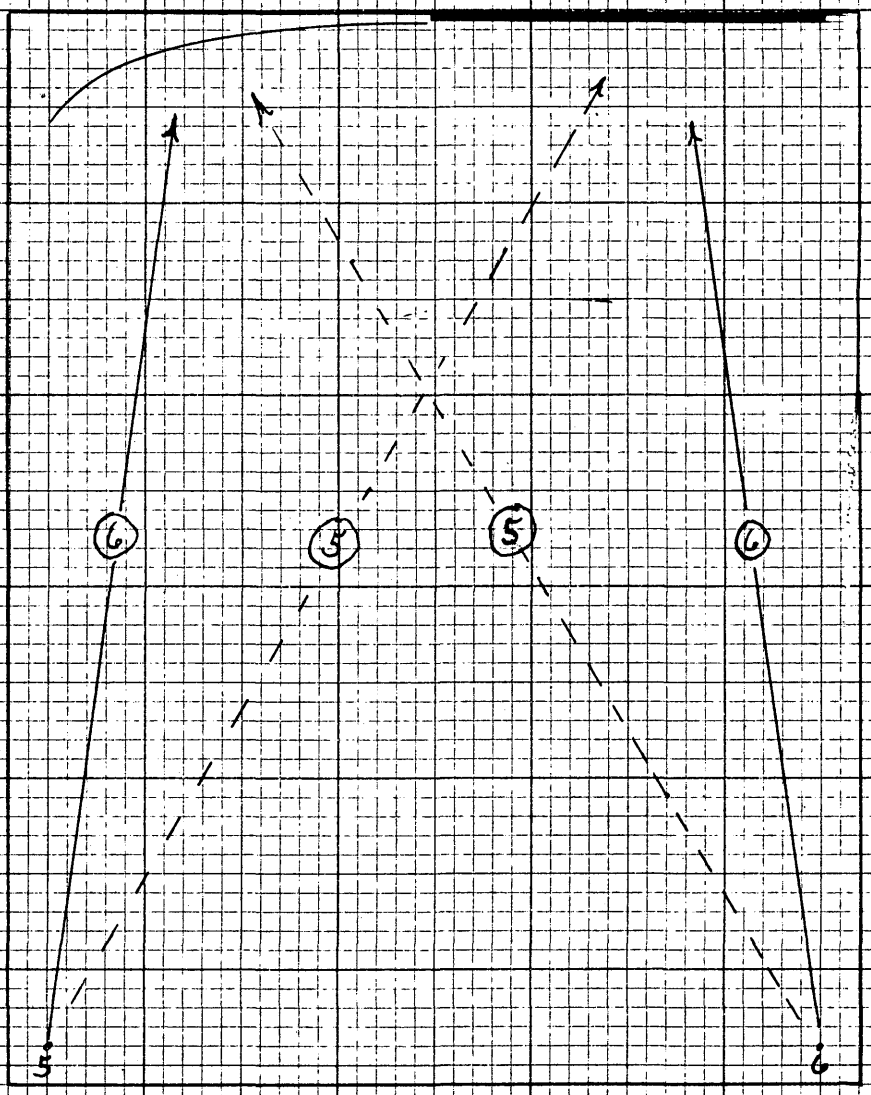

FIGURE 3

METHOD OF EXAMINING CHALKBOARDS
FROM SUBJECT VIEWING
POINTS 5 AND 6
(WILLIAMSBURG)

did the flat board. The difference was not spectacular, but the chart in Appendix I and Table VIII, page 84, indicate that the difference was significant. For example, three subjects could read the entire flat board while five subjects could read the entire curved board. In addition, all but one subject recorded a much greater percentage of readable center line on the curved board than on the flat.

Viewing Point Number Six. This was the final viewing point for the second group of subjects and like number five, was located at the rear of the classroom. There was no significant difference in the visibility of either board at this point. An examination of Appendix I and Table IX, page 85, indicated that the curved board held a very slight advantage; but, due to the limited number of observations the difference must be considered insignificant.

Conclusion. The amount of readable center line recorded for each subject on the flat board was equalled or bettered on the curved board at every viewing point tested.[3] In fact, equal performances were recorded only for those subjects who suffered from extremely poor vision or those who boasted excellent vision. The former could not read the boards while the latter could read each board in its entirety. This consideration of the improved performance of the individual, as opposed to the average

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[3]The negative percentage increase shown for subject 3a at viewing point three in Table X does not disprove this statement. The table includes only the percentage increase of that which was recorded as "readable". The subject in question could read only thirty-five per cent on the curved board, but he could "distinguish" the remaining sixty-five per cent of the flat board; he could read sixty per cent of the center line.

improvement of the groups, is most significant. The comparison of an individual's performances is not complicated by differences in vision of the other subjects: only the particular subject's vision is involved, and the difference in performance can be attributed to better visibility of the material. In Table X, page 86, the percentage of readable center line of the curved board as compared to the plane board is given for each subject at each position. The average percentage increase is also computed. The curved board was most effective when observed from viewing points one, three, and four.

II. BROKEN CIRCLE TESTS

The tests involving the detection of breaks in the small and large circles were inconclusive and the data has not been included. In the construction of these circles several errors were made which caused the data to be invalid. A thin pencil line had been drawn as a guide line for the centers of the circles. The lines had been inadvertently left on the boards at the completion of the circle construction. These pencil lines created the illusion that breaks occurred in the arcs of the circles at three and nine o'clock. Furthermore, the large circles and their breaks were of such size that they could be easily distinguished on both boards at all the viewing points; therefore, they served no use in the test. The small circles were of a suitable size, however, they had not been uniformly constructed. Chalk had been sharpened and applied with the utmost care, but accurate circles could not be constructed free hand, by means of a form device, or by means of a string radius. In each case the small

size of the circle and the necessity for clear figures formed by moderately heavy chalk pressure combined to defeat attempts to achieve accurate figures. In addition to these observations, the validity of the data was further lessened by the tendency of the subjects to give a "considered guess" as to the location of the break they knew to be present in each circle.

III. PARALLEL LINE TESTS

General. Appendix J contains a chart which depicts the results of the parallel line tests on both boards at the six viewing points.

Viewing Point Number One. From this point, all the sets of parallel lines were correctly counted on both boards by four subjects. The remainder of the subjects recorded distinct vision improvement when viewing the curved board. Table XI, page 87, lists the number of sections of each board that could be read and distinguished the same amount or more on the curved board than on the flat board. An average of 2.75 of the three sections were countable on the curved chalkboard, while 1.6 of the three sections were countable on the flat board. When compared at this viewing point the curved board was more advantageous than the plane chalkboard.

Viewing Point Number Two. Only one subject of the seven who examined the boards from this point registered a variation in the countability of the parallel sets on the two boards. Although this one difference was in favor of the curved board it must be considered insignificant. Both boards are considered equally advantageous at this viewing point.

Viewing Point Number Three. A great and significant difference may readily be noted in the performance of the boards from point three. Few of the subjects could count or distinguish any of the sets on the flat board, but every subject could count all the sets of the curved board. Table XII, page 88, lists the sections of the boards which could be counted or distinguished. On the flat board an average of fifty-five per cent of the parallel lines could be counted or distinguished by the seven subjects. As previously noted, the curved board was one hundred per cent countable. At this point, therefore, the curved board proved much more advantageous.

Viewing Point Number Four. Once again the curved board was proven more advantageous. All the subjects experienced considerable difficulty in counting or distinguishing the parallel lines on the plane chalkboard. However, only one subject (vision 20x60) failed to count every set correctly on the curved board. Such improvement of visibility is shown in Table XIII, page 89, and leaves little doubt concerning the superiority of the curved board at this viewing point.

Viewing Point Number Five. Three subjects at this position could count all lines on both boards. The remaining four subjects had difficulty on the flat board, but could count all lines on the curved board. This is not a spectacular difference, but, as may be seen in Table XIV, page 90, the average increase of readable sets was notable and is indicative of the slight advantage of the curved board at this point.

Viewing Point Number Six. There was no difference whatsoever in the visibility of the parallel lines on either board from this point. All seven subjects could count all the lines on both boards.

Conclusion. The number of sets of parallel lines which each subject recorded as countable on the flat board was equalled or bettered on the curved board at every point tested. Of the total forty-nine views which were made of the curved board only three reported difficulty in counting all the lines. In Table XV, page 91, the increase in the countable portions of the curved board as opposed to the plane board is recorded for each subject at each position. The average increase is also computed. The curved board was slightly more advantageous than the plane board when viewed from points one and five; overwhelming improvement was recorded at positions three and four.

IV. COMPARISON OF VIEWING POINTS

From the results of the center line and parallel line tests, it is clear that the curved board was equal to or better than the flat board at all viewing points tested. Furthermore, the superiority of the curved board was most noticeable at points one, three, and four. At each of these positions the increase in over-all visibility was very large. Despite the marked improvement in the curved board at point number four, an examination of Appendix H reveals that this point was virtually out of range for those with normal vision. Point number three is the point at which the curved board was most effective when all factors are considered. The first point was also extremely favorable to the curved board. At

viewing points two and five the advantage remained to the curved board, but at point number six both boards were equally visible.

V. MIDDLE AREA OF CURVED BOARD

The charts in Appendixes G, H, and I show that the middle area of the curved board was the most difficult portion to read. That is, the portion of the center line between board section numbers fourteen and twenty-eight was often difficult to read or distinguish. This "blind spot" may have been caused in part by the imperfect intersection of the two halves of the homemade board and other imperfections previously noted in Chapter II, Section III. Nevertheless, the chief cause of this "blind spot" is not attributable to board construction. The now probable cause was a combination of distance and angle which was sufficient to make the writing difficult to read. The curve tested did not provide a universal cure for the effects of small angle and large distance that has plagued vision of the flat board. Each portion of the curved board is not uniformly visible from every point within the classroom. This particular curve represents a marked improvement in board visibility but the presence of this "blind spot" is proof of its limitations.

VI. COMMENTS OF SUBJECTS

General. In Appendix K the written comments of the subjects are quoted. The participants in the Williamsburg experiment were, as noted before, college graduates holding professional and technical degrees. Their comments are, therefore, explicit and relevant.

Broken Circles. The previous discussion of the circles is further corroborated by the final comments made by the subjects. The following excerpts from the individual comments supply further proof to this statement. Subject 3b stated, "The chalk smear made it hard to tell the 'o'clock' of the openings in the circles. Also, it seemed as if some of the openings were larger than others." And subject 6b said, "A lot of the difficulty for me in seeing spaces on the circles had to do with the smudges on the board and the variation in thickness of the chalk line." Thus, the data obtained on the circles was discarded.

Center Line. In their comments, the subjects frequently referred to their inability to read the center portion of the curved board. Also, one subject complained that "the small row of letters was too small to distinguish to be a good test." The letters were small, fifteen-foot Snellen eye chart letters, and were so selected that comparative cut-off points for visibility could be obtained for each type of board in a small test room. Another comment noted the presence of non-uniform letters. But perhaps the most important comments were made concerning a tendency to recall some of the groups of numbers and letters. One subject said, "I remembered some answers given from the first chairs (viewing points)." Another wrote, "There was a tendency also to remember some of the numbers——."

Parallel Lines. No comments were made concerning the tests which utilized parallel lines.

Complaints. Two subjects commented that the last hours of the experiment were very tiring to eyes that had been worked all day and had already been used at one or two viewing points earlier in the evening.

Constructive Comments. The following are the suggestions made for effecting a more comprehensive test of the curved chalkboard. In some cases these suggestions were specifically stated, but the majority represent thoughts which have been gleaned from implications and questions contained in the written comments.

1. Determine the difference, if any, between the visibility of script lettering and printed lettering on the curved board.

2. Determine the degree of difficulty involved in writing upon a curved board.

3. Determine the effect of distortion of writing due to the curvature and ascertain its readability.

4. Repeat the experiment utilizing school children as subjects.

5. Use classroom chairs and desks for viewing points in further tests.

6. Test the curved chalkboard under daylight conditions.

7. Use a flash, recognition test of letters and numbers to determine instantaneous readability.

8. The chalkboard should be washed after each erasure.

All of these suggestions merit discussion and some contain the seeds for further investigation. Numbers four, six, and seven are considered most relevant to this particular experiment. The suggestion contained in number one is minor and has little effect upon the comparative visibility

of the two types of boards. The second suggestion does not warrant further investigation because the experimenters discovered, while placing test material upon the boards, that there was no difference in writing upon either type of chalkboard. It was noted, however, that the curvature impeded the use of a rigid straight edge to draw lines. The use of a flexible straight edge (such as that constructed of plastic) eliminated this difficulty. The third suggestion, like number one, is minor and has little effect upon a comparative study of the visibility of the two boards; furthermore, the tests utilizing parallel lines were considered determiners of the major distortion: namely, apparent compression caused by a small angle of vision. The fifth suggestion is irrelevant because the stool used in the tests was set at a height comparable to normal high school classroom chairs. Finally, smudges caused by erasure cannot be washed, as is suggested in number eight, because this would create an even greater contrast with the rest of the chalkboard, and water is not recommended for a wood fiber type board. The point is well taken, however, that greater care should have been maintained so as to eliminate variation in board contrast due to erasure.

VI. RESULTS OF PHOTOGRAPHIC COVERAGE

Color Photographs. Five color transparencies of high resolution were obtained. From these, two pictures were selected to be made into Kodachrome prints. These are contained in Appendix EE. They serve as evidence of the contrast in hue between the two boards, and show the test equipment as seen by a subject.

Black-and-White Prints. Three rolls of black-and-white pictures were taken of the flat and curved boards from the points indicated in Appendix F. Upon development of these films it was discovered that one of the rolls had been defective. A light streak appeared down the center line of the entire film. Inasmuch as the center of each picture had been focused upon the center line of the board, the pictures thus obtained were useless as evidence of comparative visibility. In addition, the picture taking procedure had not been effectively conceived. In order to avoid excessive movement of the curved board, photographs had first been taken of the flat board from all points, after which the sequence of photographs was repeated for the curved board. This procedure did not take into account the possible differences in separate rolls of film of the same type and make. Thus, most of the pictures of the curved board were lost due to the faulty film. Photographs of both the flat and curved board from each viewing point should have been taken on the same roll of film. Appendix L contains several photographs of the two types of boards which were taken from viewing points which received adequate photographic coverage. The resolution in these photographs is not sufficient to allow comparative readings of the center line of small figures, but the large letters marking the center line groups may be used for comparison.

VII. GENERAL CONCLUSIONS OF WILLIAMSBURG TEST

As a result of the test procedure and data that have been presented, discussed, and analyzed in this and the preceding chapter, the following major conclusions have been drawn concerning the tests conducted at James Blair High School.

1. The curved board was proven as visible or more visible than the flat board at every viewing point tested.

2. In comparison with the flat board, the curved chalkboard was most effective at positions one, three, and four.

3. The use of broken circles as a testing device was inadequate.

4. Greater care should have been exercised in the placement of test material upon the chalkboards.

5. The general procedure employed in testing chalkboard visibility was adequate.

6. Groups of letters and numbers, and sets of parallel lines were effective measures of board visibility.

7. Reading aloud of the center line groups tended to enable subjects to recall certain groups.

8. The vision of the first group of subjects, as a whole, was approximately equal to that of the second, but the use of two groups created an undesirable variable and made exact comparisons of viewing point performances impossible.

9. Large differences in individual reading performances at any single viewing point were caused by variation in the degree of 20x20 vision.

10. Factors affecting chalkboard visibility, with the exception of angle and distance, were held fairly constant.

11. The "blind spot" in the center of the curved board was caused largely by a combination of large distances and small angles of vision.

12. An insufficient number of viewing points were tested to determine the effectiveness of the curved board throughout the classroom.

13. The procedure employed in obtaining the series of black-and-white photographs was poorly conceived.

14. Further tests were needed to correct the errors in procedure committed thus far, to clarify and substantiate the results that appeared from these initial tests, and to compare the flat and curved boards under more varied yet rigorous conditions.

CHAPTER VI

CRADOCK TEST PREPARATIONS

I. THE SITE

Construction. Cradock High School in Portsmouth, Virginia, was selected for the second series of chalkboard tests. This was a new school, completed in the late summer of 1954. The classrooms had received one year's use before this test; however, being of cinderbrick construction, they were in excellent condition. A dual room designed for use in health education classes was chosen as the specific test site. This was a long, rectangular classroom which, when separated by a sliding partition, formed two separate classrooms of standard size (twenty-two by twenty-eight feet). One of these rooms was equipped with a side chalkboard which was so placed that the tests could be easily conducted. Removal of the sliding partition allowed lateral viewing points to be selected as desired. Figure 4, page shows the general plan of this test room. The desks and the chairs were removed from the room to allow movement of the curved board. A large table was moved into the room to support the curved board at a height equal to that of the permanent board.

Lighting. The room was equipped with fluorescent lights which diffused the light rather evenly. A light meter recorded relatively constant readings of fifteen to twenty foot-candles at various points about the room under artificial light.[1] This light was furnished by two fluorescent fixtures which each contained two bulbs. In addition, natural light was

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[1]The light meter was aimed at the same chalkboard at all positions.

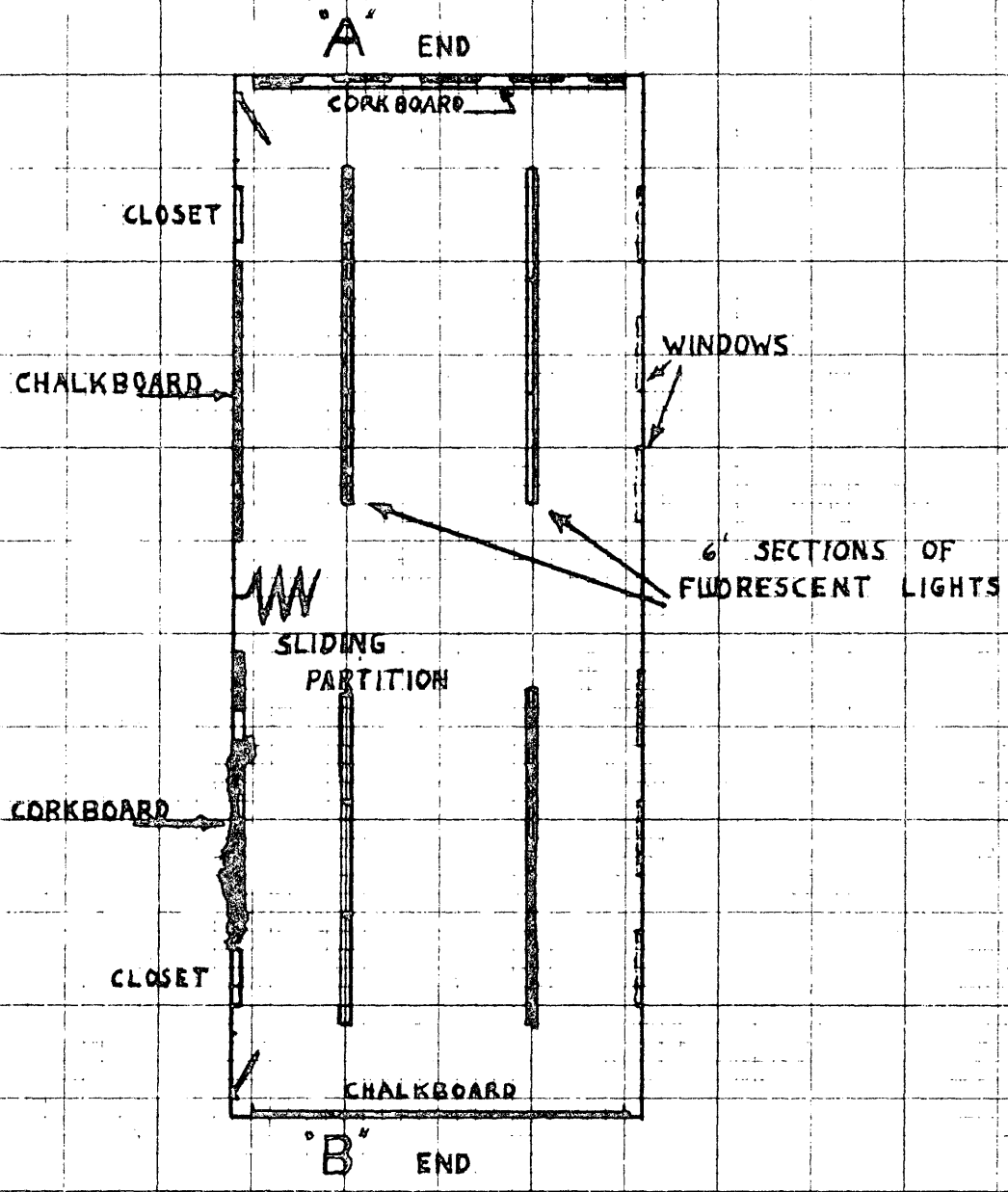

FIGURE 4

GENERAL PLAN OF CRADOCK TEST ROOM

provided from a row of six windows which were evenly spaced on the wall opposite the test chalkboard. Each window contained five panes four of which were covered with a window shade to shut out the glare of the sun. Dark green drapes were also provided.

Color Scheme and Reflectances. The half of the test room which has been designated as "A" in Figure 4 on page 44 was finished in a very pastel green which gave a reflectance reading of approximately twenty-one per cent. The floor was made of a dark green, mottled tile (reflectance twelve per cent). A white ceiling of eighty per cent reflectancy covered the entire test room. The upper two-thirds of the walls at the "B" end of the room were finished in a pastel yellow (reflectance forty per cent) and the lower one-third was finished in the pastel green previously described. The tile floor was a light grey which recorded a reflectance of seventeen per cent. Thus the room was decorated in general accordance with modern color schemes and recommended reflectances.[2] The reflectances at the "A" end of the room were slightly less than those at the "B" end—and less than those recommended. However, for the specific purposes of this test the difference was considered very slight and of no consequence in the use of the two connecting rooms. The important fact is that both rooms are in keeping with general concepts of modern classroom design.

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[2]Pamphlet No. 104 of the U. S. Office of Education recommends the construction of classrooms with reflectances as indicated in Figure 5, below.

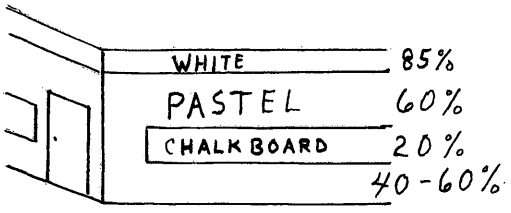

FIGURE 5. RECOMMENDED CLASSROOM REFLECTANCES

Chalkboard. The chalkboard was of the wood-fibre type and recorded a reflectance of approximately twenty per cent. It was four feet in height and the aluminum chalkrail was two and one-half feet above the floor. The chalkboard which had been selected for the test had been used very little, because it was on the side of the room. This particular chalkboard had not received much more use than the curved chalkboard.

II. SUBJECTS

Ten subjects were selected from the senior class at Cradock. Five were girls and five were boys. Each of these students had vision, or vision corrected by glasses, which had been classified as 20x20 in tests conducted by a school nurse. They were all of approximately the same age (seventeen) and had I. Q. ratings which ranged about average. Table XVI, page 92, contains all personal data which is pertinent to this discussion.

III. PREPARATION OF TEST EQUIPMENT

Form on the Boards. In order to insure equivalent chalk content on both types of the chalkboards, they were first washed and then "chalked in" with yellow chalk.[3] This chalk was of fine quality, "dustless" crayon which was well suited to the needs of the test, because it could be sharpened to a hard point for use in placing fine lettering upon the chalkboards.

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[3]The term "chalked in" is discussed in Chapter II, page 18.

Groups of Letters. Inasmuch as the use of nonsense syllables of letters and numbers had proved a successful device for determining chalkboard readability, the same type of group symbols were again employed. This time, however, they were placed in single lines at the top and bottom of each board as well as in the center. It was felt that such an arrangement would enable the visibility of all three areas to be determined and the effect of three dimensional angles of vision thus discovered. A total of thirty numbered groups of four figures were placed in each line. These groups were obtained and erected on the boards in the same manner as in the tests at Williamsburg.[4] The spacing between the groups, however, was increased to two inches so that the groups might be readily identified as separate units from the lateral viewing points. Detailed measurements which give the exact form of the chalkboards are pictured in Appendix M.

Parallel Lines. Vertical sets of parallel lines were also placed on the chalkboards. These had proven successful in determining the degree of distortion caused by the angle of vision and its distance from the viewing point. Ten sets were placed on each board: five on the upper half and five on the lower half. These lines were twelve inches long and five-sixteenths inch apart. The number of lines in each set varied between five and twelve. Appendix M illustrates the exact locations of these sets of parallel lines.

No further material was placed on either board.

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[4]See discussion in Chapter III, Section III, page 18.

Board Positions. The positions of the curved board with respect to the viewing points were obtained in the same manner as in the test at Williamsburg.[5] Exact board positions are shown in Appendix N.

Viewing Points--General. Since the classroom was but twenty-two feet wide, distant viewing points were impossible for the permanent side board. The flat board at the "B" end of the room was therefore used for all distant examinations. Material identical to that on the side flat board was placed on this end board.

Subject Viewing Points. These viewing points were marked on the floor in grease pencil. They were twelve in number and were selected at the side of the chalkboard and also well to its front. The selection was somewhat arbitrary, but it was largely determined by the results of the Williamsburg Test. Specifically, viewing point number four had been found to be virtually out of range for normal vision of the boards, and from viewing point number six both boards were proven to be equally visible. Therefore, Cradock viewing points were chosen within what was considered normal range of vision for at least a portion of each board, and outside of the area which would appear to allow total vision of each board. The twelve points which were selected are shown in Appendix O.

Photographic Viewing Points. A total of thirty-four points were selected as photographic viewing points. Only six of these points were

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[5]See discussion of board positions in Chapter III, Section III, page 20.

located within a ten-foot radius of the center of the flat chalkboard, because both boards could be easily read within most of this area. The remaining points were selected with regard to the same qualifications as the subject viewing points. The exact locations of all photographic viewing points are shown in Appendix O.

CHAPTER VII

CRADOCK TEST PROCEDURE

General. The tests were conducted during the school days on the 19th and 20th of September, 1955. Six viewing points were used on each of the test days; one point was used each class period. The over-all test procedure was very similar to that followed in the previous test.

Orientation of Subjects. Prior to the start of the tests on the first day, the ten subjects were assembled and the following information[18] was read to them.

> You have been selected as subjects for the test of a section of a new chalkboard. During this test period of two days you will be asked to come to the testing room once every class period for approximately five minutes. You will be excused from each class for ten minutes in accordance with a schedule which will be constructed.
>
> During the entire test you will please refrain from discussing any of the test, or anything connected with the test. Please keep your thoughts to yourself until after the two-day test period has elapsed. Do not discuss this with your friends, and most important—do not discuss the test amongst others in this group.
>
> Every five-minute period which you spend in the test room will be slightly different, but will conform to a general pattern. You will wait outside the door of the test room until the subject preceding you has left the room—do not wait within earshot of the door.
>
> As you enter, please walk straight to the typing chair which will be prominently placed within the room. Keep your eyes focused on the floor until you have seated yourself and you are asked to look toward the chalkboards. I will be standing with a pointer and will then ask you to tell whether or not you can clearly distinguish groups of small numbers and letters to which I will point.
>
> Each chalkboard will contain three lines of small-sized numbers and letters. The letters and numbers making up these lines will appear in groups of four. I will point to one group at a time and ask you to read them individually. Please reply immediately; do not—I repeat—do not stare at a single letter or group for any length of

time. If you should fixate on a letter for several seconds your eyes will gradually adjust and enable you to make a "good guess". We are after a quick answer of what you see at first glance.

In addition to these three lines of letters and numbers there are ten groups of parallel, vertical lines. I will point to each group and ask whether or not you can see the lines as separate and distinct. In other words, could you count the number of lines, if necessary? There will be, therefore, three possible answers: 'I cannot distinguish the separate lines'; 'I can distinguish the lines, but I cannot count them', or 'I can count them'.

As you leave the test room after each session, pick up a comment card and fill it out immediately upon your return to class—it will take about two minutes. Keep the completed card until your next session and hand it to me at that time. These cards contain several comparative questions. Please answer as you feel—make them your thoughts.

After the final session, Tuesday, sixth period, I will ask you to answer a few general questions. When all this has been completed, I will be glad to discuss any questions which you may have concerning the tests or the chalkboards.

This written orientation gave assurance that each subject received identical information, and no information which might later influence test responses.

Viewing Procedure. The subjects were ushered into the test room and seated in the same manner as those who participated in the Williamsburg tests.[6] A straight-backed chair, height seventeen inches, was provided for the subject at the viewing point. In accordance with the viewing procedure previously described, the subject was requested first to examine the groups of small letters and numbers. The visibility of the center line of the flat board was the first to be recorded. Immediately thereafter, the center

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[6]See discussion of viewing procedure in Chapter IV, Section I, page 22.

line of the curved board was viewed and the results were recorded. This procedure was then repeated for the top and bottom lines of each board. Finally, the countability of the sets of parallel lines was recorded. From time to time, the number of lines in the parallel sets was altered.

Comment Cards. Small comment cards were handed each subject at the conclusion of every viewing session. This card contained the following questions: (1) How did the two boards compare from this position? (and give your reason for thinking so); (2) List all advantages and disadvantages of each board which you noticed in this position only. These questions were answered between viewing sessions while the viewing point was fresh in the subject's mind.

Final Comments. At the completion of the tests at all twelve viewing points, the subjects were questioned concerning their over-all opinions of the test and the curved board. These questions were four in number and were repeated for each subject. The comments were obtained in recorded conversations which were held with one student at a time. The text of this taped conversation was as follows:

> You have now participated in this entire experiment. What are your over-all opinions of the curved board as opposed to the flat board? Would you like to see this board used in classrooms? Would it help you? Do you have any comments to make about the test procedure itself?

Photographic Coverage. No colored photographs were taken of this test room. Black-and-white photographs were taken from the viewing points indicated in Appendix O. These pictures were taken during the

daylight hours on a non-test day so that the same type of light (daylight and fluorescent) would be used for the photographs as was used by the subjects. A Leica camera containing Adox number fourteen film, a film of extremely high resolution, was used for these pictures. The camera was placed upon a sturdy tripod so that the lens was forty-seven inches from the floor. The shutter speed was kept constant at one-fourth of a second and the aperture remained f/5.6. Only the focus was changed from one viewing point to another. Three rolls of thirty-six exposures each were taken within the test room. Care was exercised to insure that comparable views of the flat and curved boards were taken on the same roll of film. Half a roll of pictures was taken of the flat board, then the curved board was moved in front of the permanent board and the shots were repeated. At points directly in front and within ten feet of the boards, two or more shots were taken so as to cover the entire board.

CHAPTER VIII

RESULTS AND OBSERVATIONS OF CRADOCK TESTS

General. The discussion relative to visibility factors which has been included in Chapter V is also applicable to the Cradock test. There were only two factors which were altered in this second test: (1) illumination was by the combination of fluorescent light and sunlight, and (2) yellow chalk rather than white chalk was used on the boards. As noted in Chapter V, the vision of subjects who were classified as 20x20 varied greatly and is responsible for the large differences in reading ability recorded among the subjects at each viewing point.

I. PARTICULAR VIEWING POINTS

The twelve subject viewing points are pictured in Appendix O.

Viewing Point Number One

Grouped Figures.[1] All lines of grouped figures were seen better on the curved board than on the flat board when viewed from this point. This sharp difference may be seen in the line graphs and in the adjacent tables. Table XVII, page 93, reveals that approximately forty per cent of each of the lines on the flat board could be read while eighty to ninety per cent of the curved board could be read. The upper line of

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[1] Line graphs depicting results of tests of grouped figures at Viewing Point Number One are contained in Appendix Q.

figures proved the most difficult to read of those on the curved board; the center line was read most effectively. Over-all, the curved board was slightly more than twice as effective as the plane board in presenting readable figures from this viewing point.

Parallel Sets. The sets of parallel lines were also much more visible from point number one. This large difference is shown in Table XVIII, page 94, and in the graph in Appendix P. Well over twice the number of areas of parallel sets were countable on the curved board than on the flat. Approximately ninety-six per cent of the surface of the flat board was countable and distinguishable while fifty-two per cent of the flat board was in this same category.

Consideration of General Visibility. As a result of the figures cited in the preceding two paragraphs, it appears that the curved board is approximately twice as visible as the flat board from this position. This conclusion is further substantiated by the comparison of individual improvement recorded for all the board material. Table XIX, page 95 shows a visibility increase of almost half of the entire chalkboard surface when the curved board was viewed. The center portion of the curved board was readable only to those of exceptional vision.

Viewing Point Number Two[2]

Grouped Figures. This point proved to be beyond the range of the

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[2]Line graphs depicting results of tests of grouped figures at Viewing Point Number Two are contained in Appendix R.

readability for the small figures on both types of boards. The groups were more easily distinguished, however, on the curved than on the flat board. The line graph in Appendix R points up this marked increase in distinguishability, as does Table XX, page 96. It may be noted from this table that approximately twenty-five per cent of the material on the flat board could be distinguished as opposed to approximately eighty-five per cent of that on the curved board. In this case, the lower line on the curved board proved the most visible.

Parallel Sets. None of the sets of parallel lines on the flat board could be counted. On the curved board, however, Table XXI, page 97, shows that 3.2 of the five sections of parallel line sets were countable. In fact, ninety-six per cent of the curved board could be counted or distinguished as compared to twenty-four per cent of the flat board. Inasmuch as the flat board could not be counted it is difficult to approximate the degree of improvement provided by the curved board. A comparison of both the distinguishable and countable area indicates that the curved board was approximately four times more advantageous in this position.

Consideration of General Visibility. The curved board was approximately three or four times more advantageous. This statement, of course, is based upon only the meager data which could be obtained at this viewing point. The point was out of the readability range of the small letters used in the test. Once again, the center area of the curved board was the most difficult area to see clearly.

Viewing Point Number Three[3]

Grouped Figures. Nearly half of the subjects could read all three lines of grouped letters on the curved board, but no one could read even half of any line on the flat board. The percentages of each line which were readable are shown in Table XXIII, page 99. Approximately thirty per cent of the material on the flat board could be read, while eighty-five per cent of the curved board could be read—indicating that the curved board was almost three times as effective as the conventional board.

Parallel Sets. A large difference was recorded in the countability of the sets of parallel lines at this point. All but one set of lines could be counted by all the subjects. Table XXIV, page 100, shows that an average of but two sections of parallel sets could be counted on the flat board as opposed to an average of 4.95 on the curved board. The curved board was virtually one hundred per cent visible in this regard.

Consideration of General Visibility. The discussions in the above paragraphs indicate the advantage of the curved board when viewed from this point. The visibility increase is shown in Table XXV, page 101, and indicates that more than half of the board which had been difficult to discern on the plane board became clearly visible on the curved board.

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[3]Line graphs depicting results of tests of grouped figures at Viewing Point Number Three are contained in Appendix S.

As has been noted at previous viewing points, the center portion of the curved board was the most difficult area to read. The fact that virtually all the parallel lines were readily counted on the curved board indicates that this point is the first in the test to give adequate perspective to either type of board.

Viewing Point Number Four

Grouped Figures.[4] This viewing point was within the readable range for all points on the curved board, as may be seen in Table XXVI, page 102. Once again, however, the flat board was not as readable as the curved board. On the flat board an average of two-thirds of each line of grouped figures was said to be readable by the subjects. The entire curved board was readable. This is a significant difference and one that shows that there are points from which the entire curved board may be read while only a portion of the plane board may be read with equal ease. It is impossible to estimate the numerical advantages shown by the curved board at this point.

Parallel Sets. A greater portion of the parallel lines on the flat board could be counted from this point than was the case from those points tested heretofore. Once again, the lines on the curved board proved more visible, but the difference between countability on the flat and curved boards was considerably less than at points previously tested.

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[4]Line graphs depicting results of tests of grouped figures at Viewing Point Number Four are contained in Appendix T.

Nevertheless, the curved board proved most favorable, because all but one subject could count all of the parallel lines on the curved board. This comparative visibility may be seen in Appendix P and in Table XXVII, page 103.

Consideration of General Visibility. This viewing point is within the range of clear vision of the entire curved board, but not the flat board. Therefore, it is obvious that the curved board is most advantageous and affords maximum visibility at this point. This statement is further substantiated by Table XXVIII, page 104, which shows the individual gains in readability and countability on the curved board.

Viewing Point Number Five

Grouped Figures.[5] This point, like number four, is within the range of total readability of the curved board. Only one subject, number eight, encountered difficulty in reading the entire curved board. Approximately half of each of the lines on the flat board was visible. Thus, the difference is great and significantly in favor of the curved board. The percentages in Table XXIX, page 105, give numerical substantiation to these conclusions.

Parallel Sets. The observations contained in the above paragraphs are in harmony with the results of the examination of the sets of parallel lines. That is, all of the sets of parallel lines which were on

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[5]Line graphs depicting results of tests of grouped figures at Viewing Point Number Five are contained in Appendix U.

the curved board could be counted whereas only two subjects could count all the parallel lines on the flat board. Table XXX shows that approximately 4.2 of the five set areas could be readily counted. The increase in number of sections is not spectacular, but the difference is nonetheless significant.

Consideration of General Visibility. Viewing point number five proved to be very similar to number four. Both points were within the range of clear visibility of the curved board. Point number five, however, was near the outer boundary of this range as was evidenced by the failure of subject number eight to read the entire center and upper lines of grouped figures. Table XXXI, page 107, shows the increase in visibility recorded for each subject. Since the increase is positive throughout, the superiority of the curved board in this position cannot be questioned.

Viewing Point Number Six

No data were obtained for subject number four at this point, because the school schedule prevented the subject from attending the viewing session.

Grouped Figures.[6] Several of the subjects had difficulty in reading the entire curved board; but approximately ninety per cent of the curved board could be read. Table XXXII, page 108, on the previous page shows the individual percentages for the subjects. More than twice

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[6]Line graphs depicting results of tests of grouped figures at Viewing Point Number Six are contained in Appendix V.

as much of the material on the curved board could be read as on the plane board. When reading difficulty was encountered on the curved board it occurred in the center portion.

Parallel Sets. The parallel lines were not completely countable on either board. The flat board was the least effective surface as less than half (average) of the sets could be counted. These differences are shown in Table XXXIII, page 109, and definitely favor the curved board.

Consideration of General Visibility. As has been the case at previous viewing points, a marked advantage was recorded for the curved board at point number six. As shown in Table XXXIV, page 110, all subjects showed large increases in readable and countable material when the curved board was viewed. This position was definitely beyond the range of readability for the entire curved board.

Viewing Point Number Seven

Grouped Figures.[7] The portions of the graph in Appendix W which are outlined and cross-hatched, and the asterisked numbers in the following tables, represent groups of figures that could be "read with difficulty". This term was used at this and the succeeding point to indicate groups which could not be read clearly but which could be read with no more than one or two mistakes. It is by no means an accurate measure and

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[7]Line graphs depicting results of grouped figures at Viewing Point Number Seven are contained in Appendix W.

is effective merely when a student's performance is compared with one of his previous performances rated in the same manner.

Approximately one-third of the flat board could be read while virtually the entire curved board could be read. On each board, the center line was the easiest to read, although the other lines were read nearly as well. Despite the fact that this viewing point was at a considerable distance and narrow angles from the chalkboards an effective comparison was made. The outstanding performance of the curved board may be seen in Table XXXV, page 111.

Parallel Sets. All of the subjects could count all of the parallel lines on the curved board. In comparison, only one subject could count all the parallels on the flat board and an average of only three of the five sets could be counted by the subjects. Table XXXVI, page 112, reveals the curved board's superiority at this point.

Consideration of General Visibility. The curved board was proven most advantageous at this point. The large increases in readability and countability noted in Table XXXVII, page 113, coupled with the fact that virtually the entire curved board was clearly visible to all subjects, provides strong evidence of the curved board's superiority. The flat board was two to three times less effective than the curved.

Viewing Point Number Eight

Grouped Figures.[8] One subject was recorded as "reading with difficulty" at this point. The remaining subjects reported excellent results in reading the curved board. Table XXXVIII, page 114, indicates that over ninety per cent of the curved board could be read as opposed to approximately sixty per cent of the plane board. Once again the center line was the most readable of the three lines on each type of chalkboard.

Parallel Sets. There was not a great difference recorded in the countability of the parallels on the two boards. However, it is notable that all sets were countable on the curved board while some difficulty was expressed by three subjects in counting the parallels on the plane board. Table XXXIX, page 115, contains data relative to this discussion.

Consideration of General Visibility. This viewing point was at considerable distance from the board and therefore caused the subjects some difficulty in discerning the small letters and numbers. Nevertheless, the data proved that the curved board was once again the most advantageous. Table XL, page 116, shows that the readability and countability gains were not spectacular, but were impressively positive for each subject.

Viewing Point Number Nine

An examination of the line graphs in Appendix Y and the chart in

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[8] Line graphs depicting results of grouped figures at Viewing Point Number Eight are contained in Appendix X.

Appendix O reveals that this viewing point was within the clear visibility range for both chalkboards. Indeed, no difference was recorded in the visibility of either board from this point: both boards were equally advantageous.

Final Viewing Points

The final three viewing points (numbers ten, eleven, and twelve) are in a class by themselves. From the chart in Appendix O it may be seen that each of these points was located twenty-nine feet from the front wall of the classroom. In addition, the plane chalkboard at the front of the "B" end of the room was used for these viewing points alone. The distance to the boards from each viewing point was such that the small figures written on the boards were difficult to discern; however, in most cases enough data on the visibility of the boards was obtained to permit meaningful comparisons. This was not the case with the parallel lines. At each point the parallel could easily be counted on both boards, thus rendering comparison useless. Finally, the lighting on the two boards at this end of the room was not uniform—dark areas occurred on both boards. For comparison purposes, however, the boards each received approximately the same amount of light at corresponding board areas.

Viewing Point Number Ten[9]

The subjects reported very little difference in reading the two boards from this point. It can be seen from Table XLI, page 117, that

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[9]Line graphs depicting results of grouped figures at Viewing Point Number Ten are contained in Appendix Z.

that approximately seventy-five per cent of the plane board could be read while slightly over eighty-five per cent of the curved board could be read. This shows a slight advantage for the curved board, but it cannot be considered significant. Indeed, Table XLII, page 118, shows so very little percentage increase that it must be concluded that the two boards were equally visible.

Viewing Point Number Eleven

The data obtained at this viewing point were insufficient and, hence, inconclusive. Only two or three subjects could read any material on either board. Those data which are available are contained in the line graphs in Appendix AA. All subjects reported that both boards could be distinguished equally well. In short, it can only be concluded that neither board was more visible from this point and that accurate comparison is impossible because of a lack of exacting data.

Viewing Point Number Twelve

The data gathered at this point were insufficient. The entire surface of each board was distinguishable to all subjects, but only a few subjects could read any material. An examination of the line graphs in Appendix BB shows the small amount of data that were obtained for readable material. It can be seen that the curved board was slightly more visible than the flat board, but the data are very skimpy and not significant. The two boards can only be considered equally visible from this viewing point.

II. COMMENTS BY SUBJECTS

Specific Comments. The subjects who participated in the Cradock tests submitted comments at the conclusion of each viewing session. These comments were short comparisons of the visibility of the two boards from the particular viewing points. A total of one hundred twenty comment cards were received during the entire test period. These comments were consolidated and a frequency table was compiled.

Since the comments were given in answer to questions which requested a comparison of the relative visibility of each type of board, the number of distinct, comparative phrases was rather limited. All the comparative phrases which appeared in these comments were then noted, and a frequency table was constructed. For example, the comments received at viewing point number five were listed in a column together with the frequency with which the comment was made and by whom it was submitted. The results are shown in Table XLIII on page 119. These listed comments contain more pro-curved expressions than pro-flat expressions. These phrases were products of the subjects' own thoughts and were not provoked by an outside source.

In order to achieve an objective appraisal of likes and dislikes expressed in these comments, each phrase in the frequency table was given a numerical rating in terms of its pro-ness toward the curved board. That is, those phrases which were judged most favorable to the curved board were rated plus five, while those which were most favorable to the plane board were rated minus five. Ratings of various phrases ranged from minus five to plus five and are shown in Table XLIV, page 121.

The numerical values were then compiled for each viewing point in accordance with the frequency table described in the above paragraph. These final values were positive or negative according to the addition of the signed numbers in each column. No subject was allowed to amass more than ten positive or negative points at any one viewing position. The results of this numerical evaluation appear in Table XLV on page 122. Excessive points attributed to the individuals to any one viewing point have been removed from the "corrected totals".

Analysis of Rated Comments. The ratings which were assigned to the comments were somewhat arbitrary, but they did provide a numerical evaluation of the subjects' thoughts. These comments represent feelings rather than facts and serve to qualify the findings of the actual tests. In Table XLV, page 122, the ratings given by subjects at each viewing point are totaled and the viewing points given rank standing with respect to their total scores. Positive numbers are pro-curved, while negative are pro-flat. These rankings cannot be considered exact because they are the result of arbitrary ratings. However, they are indicative of the general attitudes of the subjects toward the chalkboards. It is obvious that the subjects considered the curved board very advantageous at the first eight viewing points. At the last four points both boards were considered to be approximately equal. In short, these comments tend to substantiate the data recorded during the tests.

Concluding Comments. At the conclusion of the tests, final comments of the subjects were placed on a tape recorder. These were all-inclusive statements of the entire test which gave their opinions

concerning the effectiveness of the two types of boards and the test procedure itself. All these comments are quoted in Appendix CC exactly as they were recorded at the test site. It will suffice to note that all the statements were favorable to the curved board, and that all subjects expressed a desire to see curved boards accepted as the classroom standard. There were no critical comments made concerning the test procedure.

III. COMPARISON OF SUBJECT VIEWING POINTS

From the results of the reading and parallel line tests, it is concluded that the curved board was equal to or better than the plane board at all viewing points tested. Furthermore, the curved board proved superior at the first eight points. These points were those from which narrow angles of vision were formed and where the curved board was expected to provide the greatest improvement in board visibility. Points four and five were within the classroom area from which the entire curved board could be read. At these same points only a portion of the flat board could be read. This seems to prove that the curved board was not only more readable but also that the curved board increased the number of points from which an entire chalkboard could be read.

Viewing point number nine was within the total board viewing area for both the flat and curved boards. At the final three viewing points each board proved approximately equally visible although the points were virtually out of readable range for both boards.

Comparison of Lines of Grouped Figures. Three lines of grouped figures had been placed on each board so that the visibility of all areas

of the boards could be determined. The differences in line readability on each board were slight, but the results have shown that the center line was the most visible of the three lines at every viewing point, except numbers two and ten. This fact may be seen in Table XLVI, page 123. which lists the ranks of the lines at each point which had information sufficient to permit comparison of readable percentages. Point number two was beyond the range of accurate reading and the differences between the center and lower lines were not significant. At position number ten the center line of the flat board was the least readable—once again the viewing point lay beyond the range of accurate reading. The relatively poor readability of the upper line at each point is even more salient than the good readability of the center line. This poor showing may be attributed largely to glare. The student had to look slightly upward in order to view the upper line and in so doing he was subjected to an increase in light reflected by the board. In short, the angle of vision more nearly approximated the angle of incident light than was the case at the center line. Thus, it is concluded that although angle of vision may account for part of the slight variations in readability between the lines of figures on a single board, the major factors affecting this change are amount of light and angle of incident light.

IV. PHOTOGRAPHIC COVERAGE

Photographs were taken from the thirty-four viewing points shown on the right-hand side of Appendix C. These pictures provide visual proof of the comparative effectiveness of the two boards. The photographs

substantiate the findings of the tests, because those pictures taken from the sides of the boards show the curved board to be more readable than the flat board. In particular, photographic viewing points eleven, sixteen, seventeen, twenty-one, twenty-two, twenty-three, twenty-four, twenty-five, twenty-six, twenty-eight, twenty-nine, thirty, thirty-one, thirty-three, and thirty-four show that the curved board is more advantageous than the plane board. In the remaining positions the two boards may be seen to be of approximately equal visibility. Exception to this statement must, however, be taken at points one, two, and five. These points were directly in front of, and close to, the sharpest board curvature and the camera lens was incapable of bringing the entire curved area of the board into focus. These photographs are contained in Appendix DD.

V. GENERAL CONCLUSIONS OF CRADOCK TEST

As a result of the data which have been presented and analyzed, several general conclusions may be made concerning the tests conducted at Cradock High School.

1. The curved board was proven as visible or more visible than the flat board at every viewing point tested.

2. The curved board was most effective at points which formed narrow angles of vision on the flat board. That is, points to the side of the board were most favorable to the curved chalkboard.

3. The center line of grouped figures on each board was most easily read and the upper line was the most difficult.

4. The total board viewing area was greater for the curved board than for the flat. The entire curved board could be read from more points within the classroom than could the flat board.

5. Additional tests were needed to determine (1) the specific relationship between distance and angle of vision which together cause areas of chalkboard to be unreadable and (2) the exact classroom area from which the entire surface of each type of board might be read.

CHAPTER IX

SUMMARY AND CONCLUSIONS

I. GENERAL COMPARISON OF WILLIAMSBURG AND CRADOCK TESTS

The chalkboard tests which were conducted at Williamsburg and Cradock generally substantiated one another. At Williamsburg, the data strongly favored the curved board. These tests, however, had been hampered by errors in procedure, a lack of yellow chalk, and lack of test refinement. Nonetheless, the superiority of the curved board was easily recognized in these initial tests. The results of the Cradock tests were corroborated by those at Williamsburg. Viewing points similar to those at Williamsburg revealed similar results and appeared firmly to establish the superiority of the curved board. Its visibility was equal to, or greater than, the flat board at all positions.

II. TOTAL BOARD VIEWING AREA

The tests which have been described above proved that there existed points within the classrooms from which the entire surface of a chalkboard could be easily read. It was also shown that some of these points were the same for each type of board, and that there were others from which only the curved board could be read in its entirety. This indicated that the total board viewing area of the curved board was greater than that of the flat board.

III. GENERAL SUMMARY OF TESTS

The chalkboard tests which have been reported in this paper have provided proof of the greater visibility of a curved chalkboard as opposed

to the conventional flat board. It has been shown that the curved board enabled subjects to read small figures and count parallel lines more effectively at every position tested. Furthermore, subjects could see the entire curved board at viewing points from which only portions of the flat board could be seen. The exact degree of improvement provided by the curve has not been determined but it has been closely approximated from several different approaches.

The curved board which was tested did not provide perfect visibility from all points within a normal sized classroom. The center area of the board appeared to have a "blind spot" which was caused chiefly by large distance and small angle of vision. Tests were not conducted at every point within the classroom, and the determination of the area of total board visibility was largely theoretical. Nevertheless, the evidence unmistakably points to the use of curved chalkboards as a means of achieving better chalkboard visibility.

The limiting distances which were obtained in the tests were small. This was caused by the use of small figures as a testing device. It must be remembered that in normal classroom usage all these distances would be increased in accordance with the increase in figure size—provided all other factors, such as lighting, remain constant. A curved chalkboard, therefore, would enable classrooms to be altered so that the chalkboard might be placed on the long side of a rectangular classroom. This would create a small loss in actual floor space, but it would also eliminate the problems which have resulted from present classroom arrangement. In particular, it would virtually eliminate the necessity for

grouping students according to eyesight, it would allow teachers closer contact to numbers of a rather large class, and it would allow the teacher to read the entire chalkboard while standing relatively close to any portion of the board.

In any case, the curve is definitely advantageous; but, the question remains, "What curve will provide maximum desirable results?"

IV. AN OUTLINE FOR FUTURE RESEARCH

The results of these experiments indicate that further research is needed to determine the specific curve which will lend itself most effectively to chalkboard use. It would appear that the ellipse is very effective as a chalkboard curve, but the specific member of this family remains to be determined. It is also possible that another type of curve may better satisfy the requirements for chalkboard construction. In order to determine this, more testing is required.

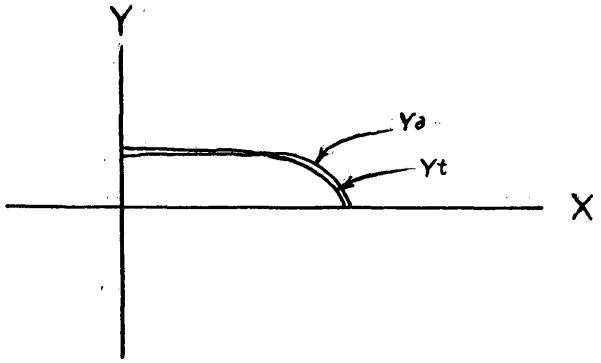
Another approach to the problem of classroom vision might evolve from the results of these initial experiments. A curved board has been shown to permit better visibility in normal rectangular classrooms. It could also be true that the classroom design could be effectively and efficiently altered so as to better conform to a particular type of curved chalkboard; it merits investigation.

TABLES

TABLE I

NUMERICAL DIFFERENCE BETWEEN CORRESPONDING POINTS ON THE THEORETICAL CURVE AND THE CONSTRUCTED CURVE AS MEASURED FROM THE X AXIS *

Feet	Inches			Feet	Inches		
X	Yt	Ya	Yt-Ya	X	Yt	Ya	Yt-Ya
0	30.00	30.00	0	6.25	23.43	24.19	-0.76
0.5	29.94	29.81	0.13	6.5	22.80	23.75	-0.95
1	29.91	29.62	0.29	6.75	22.35	23.25	-0.90
1.5	29.64	29.37	0.27	7	21.21	22.56	-1.35
2	29.40	29.00	0.40	7.2	20.82	21.94	-1.12
2.5	29.19	28.44	0.75	7.4	20.16	21.31	-1.15
3	28.62	28.12	0.50	7.6	19.50	20.56	-1.06
3.25	28.35	27.94	0.41	7.8	18.88	19.87	-.99
3.5	28.18	27.56	0.62	8	18.00	19.19	-1.19
3.75	27.78	27.37	0.41	8.2	17.16	18.37	-1.21
4	27.52	26.81	0.71	8.4	16.23	17.50	-1.27
4.25	27.16	26.81	0.35	8.6	15.30	16.56	-1.26
4.5	26.76	26.56	0.20	8.8	14.26	15.62	-1.36
4.75	26.37	26.25	0.12	9	13.08	14.62	-1.54
5	25.98	25.94	0.04	9.2	11.85	13.50	-1.65
5.25	25.41	25.50	-0.09	9.4	10.20	12.12	-1.92
5.5	24.95	25.25	-0.30	9.6	8.37	10.50	-2.13
5.25	24.54	24.87	-0.33	9.8	6.00	8.50	-2.50
6	24.00	24.56	-0.56	10	0.00	1.81	-1.81



* Yt = distance of theoretical curve, in inches, from X axis.
Ya = distance of actual curve, in inches, from X axis.

TABLE II

DATA CONCERNING WILLIAMSBURG SUBJECTS

Name	Sex	Age	Occupation	Yrs. of High School and College	Years since School	Degree	Profession	Height of Eyes	Right Eye	Left Eye	Both Eyes	Near-sighted	Glasses
Hlalock, D.	M	26	(Engineer) Service Man	9	2	B.S. Ac.E.	Aeronautical Engineer	51"	20/20	20/20	20/20	✓	✓
Cawthon, D.J.	F	23	Clerk-Typist	3	6	—	—	52"	20/20	20/20	20/20	—	—
Cawthon, D.M.	M	24	(Engineer) Service Man	8	1	M.E.	Mechanical Engineer	55"	20/20	20/20	20/20	✓	✓
Domino, C.M.	F	35	Housewife	4	14	R.N.	Nurse	50"	20/20	20/20	20/20	—	—
Hipp, J.D.	M	26	(Engineer) Service Man	8	5	B.S. M.E.	Mechanical Engineer	53"	20/20	20/20	20/20	✓	—
Hirsch, D.R.	M	25	(Clerk-Typist) Service Man	9	2	B.S. Business	Law	54"	20/20	20/20	20/20	✓	✓
Johnson, M.	F	23	Housewife	8	3	A.B.	—	50"	20/20	20/20	20/20	—	—
Johnson, T.	M	24	(Policeman) Service Man	9	2	A.B.	Criminology	52"	20/20	20/25	20/20	✓	✓
Kagen, M.I.	M	25	(Mathematician) Service Man	10	2	A.B. M.S. Math	Actuarial Mathematician	50"	20/20	20/20	20/20	✓	✓

TABLE II (continued)

Name	Sex	Age	Occupation	Yrs. of High School and College	Years since School	Degree	Profession	Height of Eyes	Right Eye	Left Eye	Both Eyes	Near-sighted	Glasses
Prigge, R.N.	M	25	(Engineer) Service Man	10	1	B. of Arch.	Architect	52"	20/200	20/60	20/60	✓	✓
Prigge, R.E.	F	23	Housewife	8	2	A.B.	Teacher	52"	20/20	20/20	20/20	—	—
Seligman, W.	M	26	(Engineer) Service Man	9	2	B.M.E.	Mechanical Engineer	49"	20/20	20/20	20/20	—	—
Thusius, P.M.	F	22	Teacher & Housewife	8	1	B.S.	Teacher	51"	20/20	20/20	20/20	✓	✓
Thusius, D.A.	M	24	(Administrator) Service Man	9	2	B.B.A.	Advertising	52"	20/20	20/20	20/20	—	—

TABLE III

ASSIGNMENT OF LETTERS TO PLAYING CARDS

IN ORDER TO OBTAIN RANDOM

LETTER SELECTION

Red Cards	Assigned Letter	Black Cards	Assigned Letter
1	A	1	N
2	B	2	O
3	C	3	P
4	D	4	Q
5	E	5	R
6	F	6	S
7	G	7	T
8	H	8	U
9	I	9	V
10	J	10	W
Jack	K	Jack	X
Queen	L	Queen	Y
King	M	King	Z

TABLE IV

PERCENTAGE OF CENTER LINE OF GROUPED FIGURES DESIGNATED AS READABLE AND DISTINGUISHABLE ON EACH BOARD BY SUBJECTS AT WILLIAMSBURG VIEWING POINT NO. 1

	Flat		Curved	
Subject	Readable	Distinguishable	Readable	Distinguishable
1a	53	0	100	0
2a	56	0	85	15
3a	41	0	88	0
4a	24	0	74	0
5a	88	0	100	0
6a	80	0	100	0
7a	100	0	100	0
1b	32	0	74	26
2b	53	0	100	0
3b	0	0	0	0
4b	53	0	100	0
5b	44	0	100	0
6b	21	0	100	0
7b	56	0	100	0
Total	611	0	1,221	41
Avg %	43.6	0	87.2	2.9
Over-all Average		43.6		90.1

TABLE V

PERCENTAGE OF CENTER LINE OF GROUPED FIGURES DESIGNATED AS READABLE AND DISTINGUISHABLE ON EACH BOARD BY SUBJECTS AT WILLIAMSBURG VIEWING POINT NO. 2

Subject	Flat		Curved	
	Readable	Distinguishable	Readable	Distinguishable
1a	60	0	100	0
2a	62	0	79	21
3a	60	0	35	65
4a	91	0	100	0
5a	91	0	100	0
6a	0	0	9	0
7a	44	0	44	32
Total	408	0	467	118
Avg %	58.3	0	66.7	17
Over-all Average	58.3		83.7	

TABLE VI

PERCENTAGE OF CENTER LINE OF GROUPED FIGURES DESIGNATED AS READABLE AND DISTINGUISHABLE ON EACH BOARD BY SUBJECTS AT WILLIAMSBURG VIEWING POINT NO. 3

	Flat		Curved	
Subject	Readable	Distinguishable	Readable	Distinguishable
1a	53	0	100	0
2a	56	0	68	32
3a	56	0	94	6
4a	50	0	100	0
5a	68	0	100	0
6a	24	0	62	0
7a	56	0	91	9
Total	363	0	615	47
Avg %	52	0	88	6.7
Over-all Average	52		94.7	

TABLE VII

PERCENTAGE OF CENTER LINE OF GROUPED FIGURES DESIGNATED AS READABLE AND DISTINGUISHABLE ON EACH BOARD BY SUBJECTS AT WILLIAMSBURG VIEWING POINT NO. 4

	Flat		Curved	
Subject	Readable	Distinguishable	Readable	Distinguishable
1b	0	0	30	44
2b	20	0	100	0
3b	0	0	12	41
4b	0	0	78	9
5b	0	0	0	0
6b	9	0	82	0
7b	0	0	35	0
Total	29	0	277	94
Avg %	3.1	0	39.6	13.4
Over-all Average	3.1		53	

TABLE VIII

PERCENTAGE OF CENTER LINE OF GROUPED FIGURES DESIGNATED AS READABLE AND DISTINGUISHABLE ON EACH BOARD BY SUBJECTS AT WILLIAMSBURG VIEWING POINT NO. 5

	Flat		Curved	
Subject	Readable	Distinguishable	Readable	Distinguishable
1b	56	0	100	0
2b	100	0	100	0
3b	38	0	56	26
4b	100	0	100	0
5b	0	0	0	0
6b	44	0	100	0
7b	100	0	100	0
Total	438	0	556	26
Avg %	62.6	0	79.4	3.7
Over-all Average	62.6		83.1	

TABLE IX

PERCENTAGE OF CENTER LINE OF GROUPED FIGURES DESIGNATED AS READABLE AND DISTINGUISHABLE ON EACH BOARD BY SUBJECTS AT WILLIAMSBURG VIEWING POINT NO. 6

	Flat		Curved	
Subject	Readable	Distinguishable	Readable	Distinguishable
1b	100	0	100	0
2b	100	0	100	0
3b	53	0	77	23
4b	100	0	100	0
5b	0	0	0	0
6b	100	0	100	0
7b	100	0	100	0
Total	553	0	577	23
Avg %	79	0	82.4	3.3
Over-all Average	79		85.7	

TABLE X

PERCENTAGE INCREASES OF READABLE CENTER LINE OF THE CURVED BOARD AS COMPARED TO THE FLAT BOARD, AT WILLIAMSBURG

	Viewing Points					
Subject	1	2	3	4	5	6
1a	47	40	47			
2a	29	17	12			
3a	47	-25	38			
4a	12	9	50			
5a	20	9	32			
6a	79	9	38			
7a	44	0	35			
1b	50			30	44	0
2b	0			80	0	0
3b	42			.2	18	24
4b	47			.8	0	0
5b	0			0	0	0
6b	47			73	56	0
7b	56			35	0	0
Average	37.1	8.4	36	35.4	17	3.4

TABLE XI

NUMBER OF SECTIONS OF EACH BOARD WHICH HAD COUNTABLE OR DISTINGUISHABLE SETS OF PARALLEL LINES AT WILLIAMSBURG VIEWING POINT NO. 1

Subject	Flat		Curved	
	Countable	Distinguishable	Countable	Distinguishable
1a	1	0	3	0
2a	1.5	0.5	2	1
3a	3	0	3	0
4a	3	0	3	0
5a	3	0	3	0
6a	1	1	3	0
7a	2	0.5	3	0
1b	2	1	3	0
2b	3	0	3	0
3b	1	2	3	0
4b	2	1	3	0
5b	0	2	0.5	2.5
6b	2	1	3	0
7b	2	1	3	0
Total	26.5	10	38.5	3.5
Average	1.6	0.7	2.75	0.25
Over-all Average	2.3		3	
Over-all Percentage	77%		100%	

TABLE XII

NUMBER OF SECTIONS OF EACH BOARD WHICH HAD COUNTABLE OR DISTINGUISHABLE SETS OF PARALLEL LINES AT WILLIAMSBURG VIEWING POINT NO. 3

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1a	1	0	3	0
2a	1	0	3	0
3a	1	0	3	0
4a	2	0	3	0
5a	2	0.5	3	0
6a	2	0	3	0
7a	2	0	3	0
Total	11	0.5	21	0
Average %	1.57	0.07	3	0
Over-all average	1.64		3	
Over-all percentage	55%		100%	

TABLE XIII

NUMBER OF SECTIONS OF EACH BOARD WHICH HAD COUNTABLE OR DISTINGUISHABLE SETS OF PARALLEL LINES AT WILLIAMSBURG VIEWING POINT NO. 3

Subject	Flat		Curved	
	Countable	Distinguishable	Countable	Distinguishable
1b	0	0	3	0
2b	1	0	3	0
3b	0.5	1	3	0
4b	0.5	0	3	0
5b	0	1	1	1
6b	0	0	3	0
7b	0	1	3	0
Total	2	3	19	1
Avg %	0.29	0.43	2.7	0.14
Over-all average	0.72		2.84	
Over-all percentage	24%		95%	

TABLE XIV

NUMBER OF SECTIONS OF EACH BOARD WHICH HAD COUNTABLE OR DISTINGUISHABLE SETS OF PARALLEL LINES AT WILLIAMSBURG VIEWING POINT NO. 5

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1b	1.5	1.5	3	0
2b	3	0	3	0
3b	3	0	3	0
4b	2	1	3	0
5b	1	1	3	0
6b	2.5	0.5	3	0
7b	3	0	3	0
Total	16	4	21	0
Avg %	2.3	.57	3	0
Over-all average	2.9		3	
Over-all percentage	97%		100%	

TABLE XV

AREA INCREASE OF THE SETS OF PARALLEL LINES ON THE CURVED BOARD AS OPPOSED TO THE FLAT BOARD AT WILLIAMSBURG

	Viewing Points					
Subject	1	2	3	4	5	6
1a	2	0	2			
2a	0.5	1	2			
3a	0	0	2			
4a	0	0	1			
5a	0	0	1			
6a	2	0	1			
7a	1	0	1			
1b	1			3	1.5	0
2b	0			2	0	0
3b	2			2.5	0	0
4b	1			2.5	1	0
5b	0.5			1	2	0
6b	1			3	0.5	0
7b	1			3	0	0
Avg increase	0.86	0.16	1.57	2.43	0.71	0
Percentage increase	29%	5%	52%	81%	24%	0

TABLE XVI

DATA CONCERNING CRADOCK SUBJECTS

Subjects	Sex	Age	Class	I.Q.	Name of I.Q. Test	Date of Test	Averages Fr.	Soph.	Jr.	Ht. of Eyes	Right Eye	Left Eye	Both Eyes	Glasses
1	M	17	Senior	113	California Short Form Test of Mental Maturity Intermediate 150 Short Form	10/3/51	A	B	B^+	48"	20/20	20/20	20/20	
2	M	17	Senior	109	Same as above	10/3/51	C^+	C	C^+	50"	20/20	20/20	20/20	
3	F	17	Senior	90	Same as above	10/3/51	C	B^-	B^-	48"	20/20	20/20	20/20	
4	F	17	Senior	108	California Short Form Test of Mental Maturity Intermediate 147 Short Form	5/2/53	B^-	A	B	48"	20/20	20/20	20/20	
5	F	16	Senior	104	Same as No. 1	11/4/55	A^-	A^-	A^-	47"	20/20	20/20	20/20	
6	M	17	Senior	102	Same as No. 1	11/4/55	B^-	D	C	47"	20/20	20/70	20/20	✓
7	M	17	Senior	103	Same as No. 4	2/14/51	B^+	B^-	B^+	49"	20/20	20/20	20/20	
8	F	17	Senior	105	Same as No. 1	11/4/55	A^-	B^-	B^+	48"	20/20	20/20	20/20	
9	M	17	Senior	105	Same as No. 1	11/4/55	C^+	B	C	51"	20/20	20/20	20/20	
10	F	17	Senior	84	Same as No. 4	3/27/51	D	D	D	47"	20/20	20/20	20/20	

TABLE XVII

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES

WHICH WERE CLASSIFIED AS READABLE

AND DISTINGUISHABLE FROM

VIEWING POINT NO. 1

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	43		43		40		87		93		100	
2	30		37		37		77		87		87	
3	33		33		37		73		80		73	
4	37		43		40		100		90		90	
5	43		50		43		93		90		93	
6	40		43		43		77		90		80	
7	43		47		43		93		100		100	
8	30		30		27		40		77		53	
9	33		37		37		77		100		100	
10	37		40		37		80		100		100	
Total	399		403		383		797		917		876	
Avg. %	39.9		40.3		38.3		79.7		91.7		87.6	

TABLE XVIII

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 1

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	2	0	5	0
2	2	1.5	5	0
3	1	1	4	1
4	2	1	5	0
5	1	1	4	1
6	2	1	5	0
7	2	0.5	5	0
8	2	1	5	0
9	2	1	3	0.5
10	1	1	4	0.5
Avg. %	1.7	0.9	4.5	0.3
	2.6	52%	4.8	96%

TABLE XIX

THE PERCENTAGE INCREASE OF READABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 1

Subject	Readable Group Increase Percentage			Countable Section Increase
	Upper	Center	Lower	
1	44	50	60	3
2	47	50	50	3
3	40	47	36	3
4	63	37	50	3
5	50	40	50	3
6	37	47	37	3
7	50	53	57	3
8	10	47	26	1
9	44	63	63	3
10	43	60	63	25
Avg. %	38.5	49.4	36.6	2.5

TABLE XX

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES

WHICH WERE CLASSIFIED AS READABLE

AND DISTINGUISHABLE FROM

VIEWING POINT NO. 2

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	23		30		30		70		97		90	
2	23		20		33		87		87		100	
3	20		20		20		83		97		90	
4	27		33		17		67		63		77	
5	27		27		33		63		80		83	
6	27		33		30		80		83		77	
7	20		37		27		100		100		100	
8	30		17		30		100		100		90	
9	17		20		27		73		100		97	
10	13				13		47		63		87	
Total	223		260		261		770		870		891	
Avg. %	22.3		26.0		26.1		77.0		87.0		89.1	

TABLE XXI

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 2

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	0	1	4	1
2	0	1	2	3
3	0	1	5	0
4	0	1	2	3
5	0	1	3.5	0.5
6	0	1	3	2
7	0	1	1	4
8	0	0.5	3	1
9	0	1	4.5	0.5
10	0	3	4	1
Avg.	0	1.2	3.2	1.6
%	1.2	24%	4.8	96%

TABLE XXII

THE PERCENTAGE INCREASE OF DISTINGUISHABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 2

	Distinguishable Group Increase Percentage			Countable Section
Subject	Upper	Center	Lower	Increase
1	47	67	60	4
2	64	67	67	2
3	60	74	70	5
4	47	43	60	2
5	36	47	50	3.5
6	53	56	47	3
7	80	67	73	1
8	70	63	60	3
9	56	83	70	4.5
10	34	43	74	4
Average	54.7	61	63.1	3.2

TABLE XXIII

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES

WHICH WERE CLASSIFIED AS READABLE

AND DISTINGUISHABLE FROM

VIEWING POINT NO. 3

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	47		50		47		100		100		100	
2	27		30		23		93		90		93	
3	23		27		23		87		100		90	
4	30		23		27		83		83		80	
5	40		43		37		100		97		100	
6	20		23		17		73		73		60	
7	30		40		37		100		100		100	
8	17		3		7		33		43		20	
9	20		23		20		97		100		97	
10	37		33		33		73		97		97	
Total	291		296		271		819		883		837	
Avg. %	29.1		29.6		27.1		81.9		88.3		83.7	

TABLE XXIV

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 3

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	3	2	4.5	
2	2	1	5	0.5
3	2	3	5	0
4	1	4	5	0
5	2	1	5	0
6	2	1	5	0
7	2	1	5	0
8	2	1	5	0
9	2	2	5	0
10	2	3	5	0
Average	2	1.9	4.95	0.05
	3.9	78%	5	100%

TABLE XXV

THE PERCENTAGE INCREASE OF READABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 3

	Readable Group Increase Percentage			Countable Section
Subject	Upper	Center	Lower	Increase
1	53	50	53	1.5
2	66	60	70	3
3	64	73	67	3
4	53	50	57	4
5	60	44	63	3
6	53	50	43	3
7	70	60	63	3
8	16	40	13	3
9	77	77	77	3
10	36	64	64	3
Avg.	54.8	56.8	57	2.95

TABLE XXVI

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES

WHICH WERE CLASSIFIED AS READABLE

AND DISTINGUISHABLE FROM

VIEWING POINT NO. 4

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	73		80		77		100		100		100	
2	67		60		67		100		100		100	
3	57		67		67		100		100		100	
4	60		70		67		100		100		100	
5	63		63		60		100		100		100	
6	53		57		57		100		100		100	
7	80		80		80		100		100		100	
8	40		43		47		100		100		100	
9	80		70		60		100		100		100	
10	53		57		50		100		100		100	
Total	626		647		632		1000		1000		1000	
Avg. %	62.6		64.7		63.2		100		100		100	

TABLE XXVII

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 4

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	4	1	4	1
2	4.5	0.5	5	0
3	4	1	5	0
4	4	1	5	0
5	4	1	5	0
6	3	2	5	0
7	5	0	5	0
8	4	1	5	0
9	4	1	5	0
10	3	2	5	0
Average	3.95	1.05	4.9	0.1
	5	100%	5	100%

TABLE XXVIII

THE PERCENTAGE INCREASE OF READABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 4

Subject	Readable Group Increase Percentage			Countable Section Increase
	Upper	Center	Lower	
1	27	20	23	0
2	33	40	33	0.5
3	43	33	33	1
4	40	30	33	1
5	37	37	40	1
6	47	43	43	2
7	20	20	20	0
8	60	57	53	1
9	20	30	40	1
10	47	43	50	2
Avg.	37.4	35.3	36.8	0.95

TABLE XXIX

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES WHICH WERE CLASSIFIED AS READABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 5

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	67		70		67		100		100		100	
2	60		57		53		100		100		100	
3	63		67		70		100		100		100	
4	53		60		57		100		100		100	
5	67		77		60		100		100		100	
6	40		37		33		100		100		100	
7	67		70		70		100		100		100	
8	30		47		57		80		90		100	
9	63		63		57		100		100		100	
10	70		57		60		100		100		100	
Total	521		605		584		980		990		1000	
Avg. %	52.1		60.5		58.4		98.0		99.0		100	

TABLE XXX

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 5

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	5	0	5	0
2	4.5	0.5	5	0
3	5	0	5	0
4	4	1	5	0
5	4	1	5	0
6	3	2	5	0
7	4	1	5	0
8	4.5	0.5	5	0
9	4	1	5	0
10	4	1	5	0
Average	4.2	0.8	5	0

TABLE XXXI

THE PERCENTAGE INCREASE OF READABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 5

Subject	Readable Group Increase Percentage			Countable Section Increase
	Upper	Center	Lower	
1	33	30	33	0
2	40	43	47	0.5
3	37	33	30	0
4	47	40	43	1
5	33	23	40	1
6	60	63	67	2
7	33	30	30	1
8	50	43	43	0.5
9	37	37	43	1
10	30	43	40	1
Avg.	40	38.5	41.6	0.8

TABLE XXXII

THE PERCENTAGES OF THE LINES OF GROUPED

FIGURES WHICH WERE CLASSIFIED AS

READABLE AND DISTINGUISHABLE

FROM VIEWING POINT NO. 6

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	13		20		17		60		63		60	
2	43		50		43		87		87		90	
3	40		37		43		83		83		83	
4	-		-		-		-		-		-	
5	47		63		63		100		100		100	
6	27		30		30		73		90		87	
7	20		50		43		97		100		100	
8	50		53		37		100		100		93	
9	33		53		47		90		100		100	
10	27		27		20		83		97		80	
Total	300		383		343		773		820		793	
Avg. %	33		42.6		38		86		91		88	

TABLE XXXIII

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 6

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	2	2.5	5	0
2	1	2	4	1
3	4	1	5	0
4	-	-	-	-
5	2	1	4	1
6	1.5	2.5	5	0
7	1	2	4.5	0.5
8	1	3	5	0
9	2	1	5	0
10	4	1	5	0
Average	2.06	1.8	4.72	0.28

TABLE XXXIV

THE PERCENTAGE INCREASE OF READABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 6

Subject	Readable Group Increase Percentage			Countable Section Increase
	Upper	Center	Lower	
1	47	43	43	3
2	44	37	47	3
3	43	46	40	1
4	-	-	-	-
5	53	37	37	2
6	46	60	57	3.5
7	77	50	57	3.5
8	50	47	56	4
9	57	47	53	3
10	56	73	60	1
Avg.	52.6	49	49.2	2.7

TABLE XXXV

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES WHICH WERE CLASSIFIED AS READABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 7

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	43		33		40		97		100		100	
2	23		20		23		83		83		77	
3	23		27		27		83		93		93	
4	30		23		27		100		100		100	
5	17		23		13		100		100		100	
6	53*		50*		40*		100*		100*		87	
7	20		33		30		97		100		100	
8	57*		60*		53*		100*		100*		100*	
9	30		47		43		87		97		100	
10	33		37		23		97		97		100	
Total	309		353		323		944		970		957	
Avg. %	30.9		35.3		32.3		94.4		97.0		95.7	

TABLE XXXVI

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 7

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	3	2	5	0
2	2	2	5	0
3	5	0	5	0
4	2	3	5	0
5	2	2	5	0
6	2	3	5	0
7	3	2	5	0
8	3.5	1.5	5	0
9	3	2	5	0
10	4	1	5	0
Average	2.95	1.85	5	0

TABLE XXXVII

THE PERCENTAGE INCREASE OF READABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 7

	Readable Group Increase Percentage			Countable Section
Subject	Upper	Center	Lower	Increase
1	54	67	60	2
2	60	63	54	3
3	60	66	76	0
4	70	77	73	3
5	83	77	87	3
6	47*	50*	47*	3
7	77	67	70	2
8	43*	40*	47*	1.5
9	57	50	57	2
10	64	60	73	1
Avg.	61.5	61.7	64.4	2

TABLE XXXVIII

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES WHICH WERE CLASSIFIED AS READABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 8

Subject	Flat						Curved					
	Upper		Center		Lower		Upper		Center		Lower	
	R	D	R	D	R	D	R	D	R	D	R	D
1	83		90		90		100		100		100	
2	17		37		30		23		80		83	
3	43		50		43		90		100		100	
4	53		60		53		93		100		100	
5	47		47		47		100		87		83	
6	30		27		37		93		87		73	
7	60		70		70		100		100		100	
8	100*		100*		100*		100*		100*		100*	
9	77		60		53		97		100		100	
10	53		53		40		100		100		100	
Total	563		594		563		896		954		939	
Avg. %	56.3		59.4		56.3		89.6		95.4		93.9	

TABLE XXXIX

NUMBER OF BOARD AREAS WHOSE SETS OF PARALLEL LINES WERE RECORDED AS COUNTABLE AND DISTINGUISHABLE FROM VIEWING POINT NO. 8

	Flat		Curved	
Subject	Countable	Distinguishable	Countable	Distinguishable
1	5	0	5	0
2	3.5	1.5	5	0
3	5	0	5	0
4	4	1	5	0
5	3	2	5	0
6	5	0	5	0
7	5	0	5	0
8	5	0	5	0
9	5	0	5	0
10	5	0	5	0
Average	4.55	0.45	5	0

TABLE XL

THE PERCENTAGE INCREASE OF READABLE LINES OF GROUPED FIGURES AND SECTION INCREASE OF COUNTABLE SETS RECORDED IN FAVOR OF THE CURVED BOARD AT POINT NO. 8

Subject	Readable Group Increase Percentage Upper	Center	Lower	Countable Section Increase
1	17	10	10	0
2	6	43	53	1.5
3	47	50	57	0
4	40	40	47	1
5	53	40	36	2
6	63	60	36	0
7	40	30	30	0
8	0	0	0	0
9	20	40	47	0
10	47	47	60	0
Avg.	33.3	36	37.6	0.5

TABLE XLI

THE PERCENTAGES OF THE LINES OF GROUPED FIGURES

WHICH WERE CLASSIFIED AS READABLE

FROM VIEWING POINT NO. 10

	Flat			Curved		
Subject	Upper	Center	Lower	Upper	Center	Lower
1	100	100	100	100	100	100
2	27	0	0	27	100	67
3	97	100	100	100	100	100
4	100	100	100	100	100	100
5	100	100	100	100	100	100
6	50	63	83	77	100	100
7	100	100	100	100	100	100
8	0	0	0	0	0	0
9	97	100	100	100	100	100
10	93	93	93	100	97	100
Total	764	756	776	804	897	867
Avg. %	76.4	75.6	77.6	80.4	89.7	86.7

TABLE XLII

THE PERCENTAGE INCREASE OF READABLE

GROUPS OF FIGURES FROM

POINT NO. 10

	Readable group Increase percentage		
Subject	Upper	Center	Lower
1	0	0	0
2	0	100	67
3	3	0	0
4	0	0	0
5	0	0	0
6	27	37	17
7	0	0	0
8	0	0	0
9	3	3	0
10	7	4	7
Avg.	4	14.4	9.1

TABLE XLIII

FREQUENCY TABLE OF COMMENTS GIVEN BY CRADOCK

SUBJECTS AT EACH VIEWING POINT

Comment No.		Viewing points 1	2	3	4	5	6	7	8	9	10	11	12
1	Like curve best			1	1	1	5	1,6	1,7	8		7	2,8
2	Like flat best												1
3	Both are equal				5	10			10	2,4,7	10	1,10	
4	Little difference						6,10		1,2,5	3	2,9	2,5	6
5	Large difference a. Curve; b. Flat	1,3,7	1,2,5 7,8	8	2	2,5,6 9	3	3,2					2(b)
6	Read both				2,5	2			2,8	1,3,4 6,9	3,4,5		5
7	Figures on flat become solid line	1,2,4 7,8,9	1,4,7 8,9	8,9 10	3,4,8 9	1,8	1,3,8	1,4	3,4,9				
8	Flat difficult to read	3		1,3,5 7	1,7	3,5,7	3,6,7 9	6,7,8	6			3,9	3,4
9	Flat harder to read	10	1,2,3	2,6	2,6	9	2	3,9	1			6	6
10	Flat easier to read									5,10	1,9		
11	Curve easier to read	1,5,9 8,9	2,3,6 8	2,4,5 7,8,10	2,3,7 8	2,3,5 7	2,3,6 7,8,9	2,3,5 7,10	2,5,6 7,8,9	3	2,3,4 6,8	3,5,6 8	3
12	Read all of curve			1	1,3,4 6,9	1,4,6 9	3	1	4				
13	Blindspots in center of curve	1,6	3,4,5 6	9			1	5					9 1,5,9

TABLE XLIII (CONTINUED)

Comment No.	Comments	Viewing points 1	2	3	4	5	6	7	8	9	10	11	12
14	Distortion on curve	1	1							1,5,6 10	1,4,5 6		
15	See further (more) on curve	2,4,6 10	3,4 10	2,4	5,7	4,7 10	5,7	2,5,7 10	5				
16	Ends of curved board are clear	1,5	4,9									8	
17	Curve: letters clearer	6,7	2,5,6 7,8	5,6,7 8	5,7	2,6	2,3	1,2,5	1,3,5	8	2,8	2,4	2,3
18	Curve: less eye strain	2	2	2	2		2,7,9	9	8	9	8		2
19	Curve: read all but center area	2,4,8 9	1,9			8	1	4	3				
20	Curve: all clearly visible		1,8	8,9	1,8	8,6	2,7,8	6,8					4
21	Curve: appeared nearer			4				7,10				9	

Numbers in columns refer to subjects.

TABLE XLIV

NUMERICAL RATINGS WHICH HAVE BEEN ASSIGNED TO COMMENTS MADE BY CRADOCK SUBJECTS* IN ACCORDANCE WITH THE DEGREE OF PRAISE FOR THE CURVED BOARD CONTAINED IN THE EVALUATION

	Refer to flat				Refer to curved				
	Pro		Con		Pro		Con		Neutral
Numbered comments	10	2	8	7	11	16	1	13	3, 6, 4
	5b			9	15	17	19	14	
					18		20		
					5a		21		
							12		
Assigned ratings	-5	-1	1	2	5	2	1	-4	0

* Table XLIII lists the comments received.

TABLE XLV

TOTALS OF RATINGS APPLIED TO COMMENTS* OF EACH CRADOCK SUBJECT, AND RANK ORDER OF VIEWING POINTS RESULTING FROM GRAND TOTALS OF RATINGS

	Viewing points											
Subject	1	2	3	4	5	6	7	8	9	10	11	12
1	14-8	11-14	3	4	4	3-1	6	5	-4	-9	0	-1
2	13	19	17	17	12	15	17	10	0	7	0	8-5
3	6	12-4	1	8	6	16	12	5	5	5	6	8
4	8	9-4	11	3	6	0	3	3	0	5-4	2	2
5	7	7-4	8	7	11	6	12	12	-9	-4	5	8
6	7-4	7-4	4	3	9	6	3	6	-4	5-4	7	2
7	14	9	8	13	11	17	12	6	0	0	1	-4
8	8	15	15	8	4	8	2	10	3	7	7	1
9	8	5		3	8	11	7	7	5	-5	2	-4
10	7	5	7	0	5	0	11	0	-9	0	0	0
True total	80	79	73	66	76	81	83	64	-13	3	30	15
Corrected total**	69	52	60	56	72	62	69	64	-13	3	30	15
Rank order	2	7	5	6	1	4	2	3	11	10	8	9

* Table XLIII contains comment frequency chart, and Table XLIV contains ratings given to each comment.

** No subject was allowed to amass more than ten positive or negative points at any one viewing position.

TABLE XLVI

RANKED ORDER OF MOST READABLE LINES ON FLAT AND CURVED BOARDS AT VIEWING POINTS WITH SUFFICIENT DATA FOR RANKING

Viewing point	Flat			Curved		
	Upper	Center	Lower	Upper	Center	Lower
1	2	1	3	3	1	2
2	2	1	1	3	2	1
3	2	1	3	3	1	2
4	3	1	2		insufficient data	
5	3	1	2		insufficient data	
6	3	1	2	3	1	2
7	3	1	2	3	1	2
8	2	1	2	3	1	2
10	2	3	1	3	1	2

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APPENDIXES

LIST OF APPENDIXES

APPENDIX	NOMENCLATURE
Q.	Cradock Viewing Point No. 1
R.	Cradock Viewing Point No. 2
S.	Cradock Viewing Point No. 3
T.	Cradock Viewing Point No. 4
U.	Cradock Viewing Point No. 5
V.	Cradock Viewing Point No. 6
W.	Cradock Viewing Point No. 7
X.	Cradock Viewing Point No. 8
Y.	Cradock Viewing Point No. 9
Z.	Cradock Viewing Point No. 10
AA.	Cradock Viewing Point No. 11
BB.	Cradock Viewing Point No. 12
CC.	Final Comments of Cradock Subjects Tape Recorded
DD.	Cradock Photographs
EE.	Colored Photographs of Test Equipment and Its Arrangement

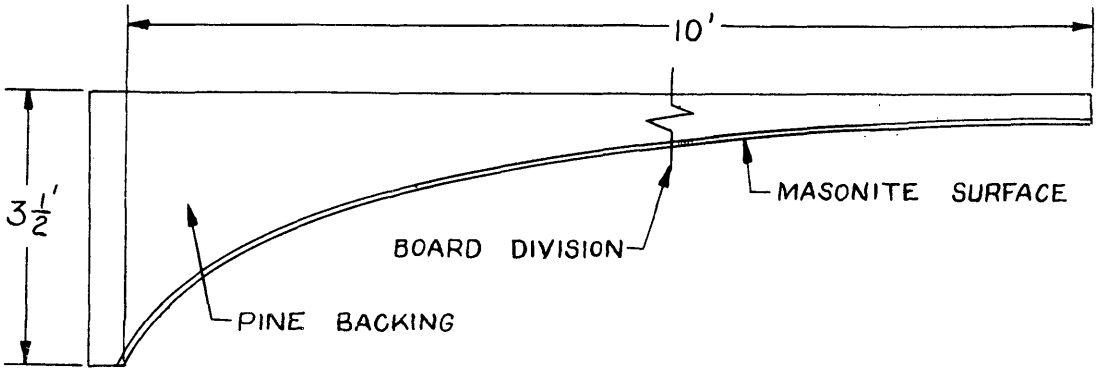
CONSOLIDATED DATA SHEET ON STATE REPLIES

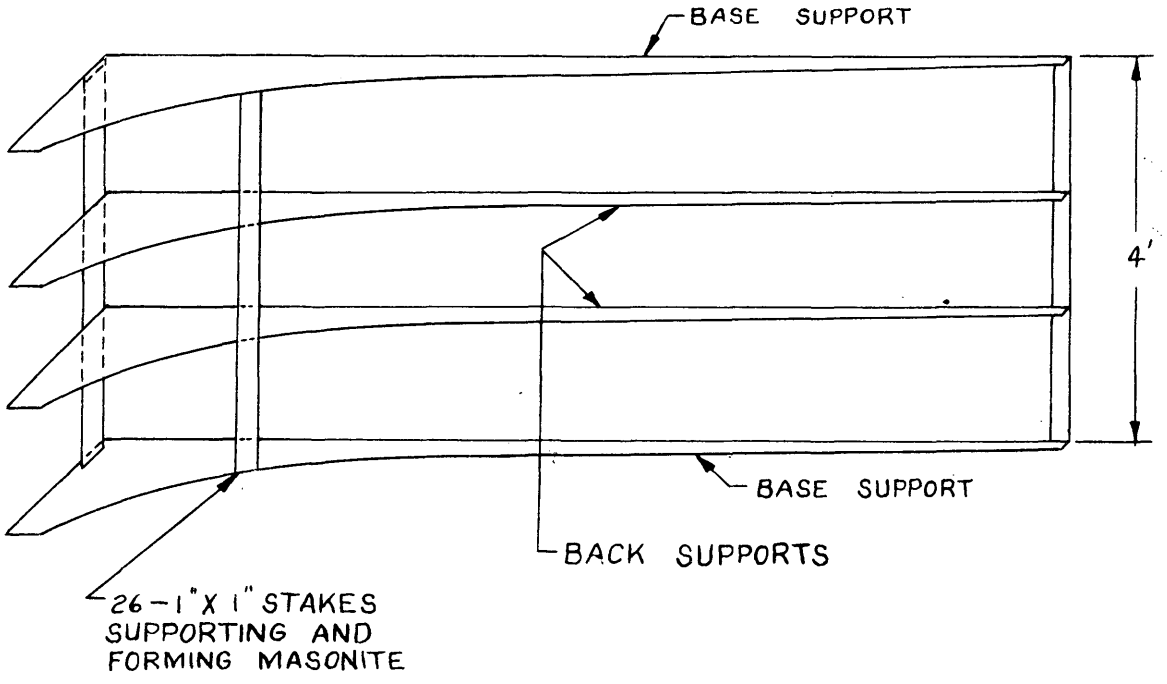
		Make Color	Slate		Composition			
	Returned	Recommendations	Green	Black	Green	Black	Other	L
Alabama	yes	no						
Alaska								
Arizona								
Arkansas								
California	yes	yes	A	A	A	A	A	
Colorado	yes	no	A	A	A	A	A	
Connecticut	yes	no	A	A	A	A	A	
Delaware								
Florida	yes	no	A	A	A	A	A	
Georgia	yes	yes	A	A	R	A	A	
Hawaii	yes	yes			R			
Idaho								
Illinois	yes	no	A	A	A	A	A	
Indiana	yes	no	A	A	A	A	A	
Iowa	yes				R			
Kansas	yes				R			
Kentucky	yes	yes	R		R			
Louisiana								
Maine								
Maryland	yes	no						
Massachusetts								
Michigan								
Minnesota								
Mississippi	yes				R			
Missouri								
Montana	yes	yes	R		R			
Nebraska								
Nevada								
New Hampshire								
New Jersey	yes	yes			R			
New Mexico	yes	no	A	A	A	A	A	
New York	yes	yes	A	A	A	A	A	
North Carolina	yes	yes	A	A	R	A	A	
North Dakota	yes				R	@		
Ohio	yes	no	A	A	A	A	A	
Oklahoma								
Oregon	yes	yes			R			
Pennsylvania	yes	no	A	A	A	A	A	
Rhode Island								
South Carolina								
Tennessee	yes	yes			R			
Texas	yes	no	A	A	A	A	A	
Utah	yes	no	A	A	A	A	A	
Vermont	yes	yes	R					
Virginia	yes	no	A	A	A	A	A	apr
Washington								
West Virginia	yes	no	A	A	A	A	A	
Wisconsin	yes				R			
Wyoming	yes	no	A	A	A	A	A	

R---is used to indicate a strong recommendation by the state.
A---means general acceptance. @---refers to a specific requirement made by the sta

APPENDIX B

SPECIFICATIONS OF PROTOTYPE BOARD





APPENDIX D

TABLE OF RANDOM LETTERS AND NUMBERS DERIVED ESPECIALLY FOR CHALKBOARD TESTS*

RANDOM LETTERS

R H G D O C J I E P U A X V R

Z F Y Y V E M S H D L J W K X

U C A M C Z Q F W K Q S G B I

T O N B N L V U B Q T U Y R P

V H K M G M T N L K H X L F Z

E F I Y D O O D G A C B Q R S

N E I J C O A Z J W X W P

RANDOM NUMBERS

6 7 1 9 8 5 6 4 2 9 1 5 8 2 4

5 4 8 5 4 3 7 3 6 6 3 9 1 2 7

1 7 3 2 8 9 6 7 6 9 6 4 5 2 1

8 7 2 3 7 5 9 8 5 9 4 1 3 5 1

2 6 8 4 3 1 2 4 8 7 3 9 5 8 2

7 4 2 9 8 4 6 4 2 3 8 6 9 2 5

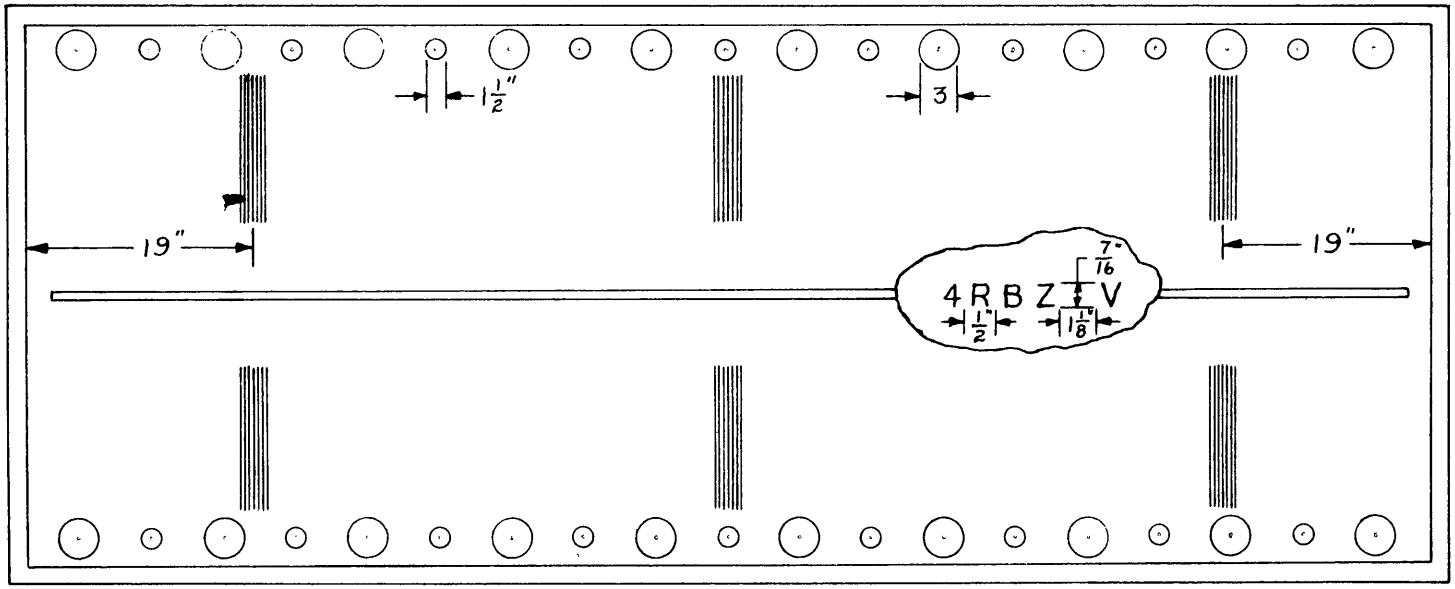
3 7 7 6 1 1 5 9 5 9 4 3 3 6 1

1 7 8

* Refer to Table IV for derivation of numbers and letters.

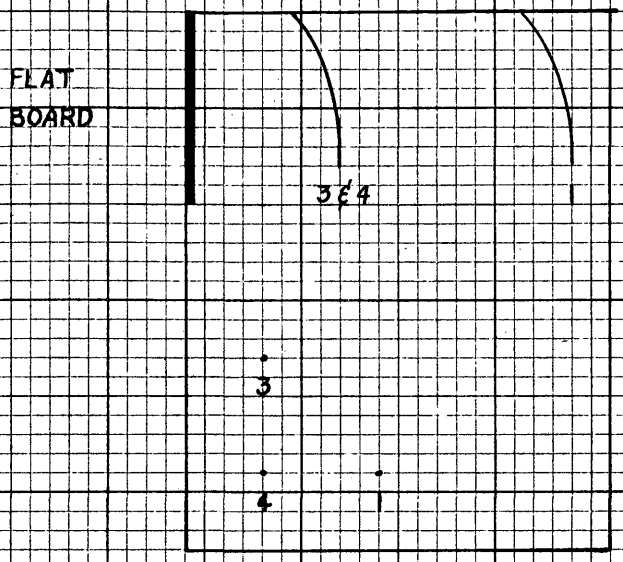
APPENDIX C

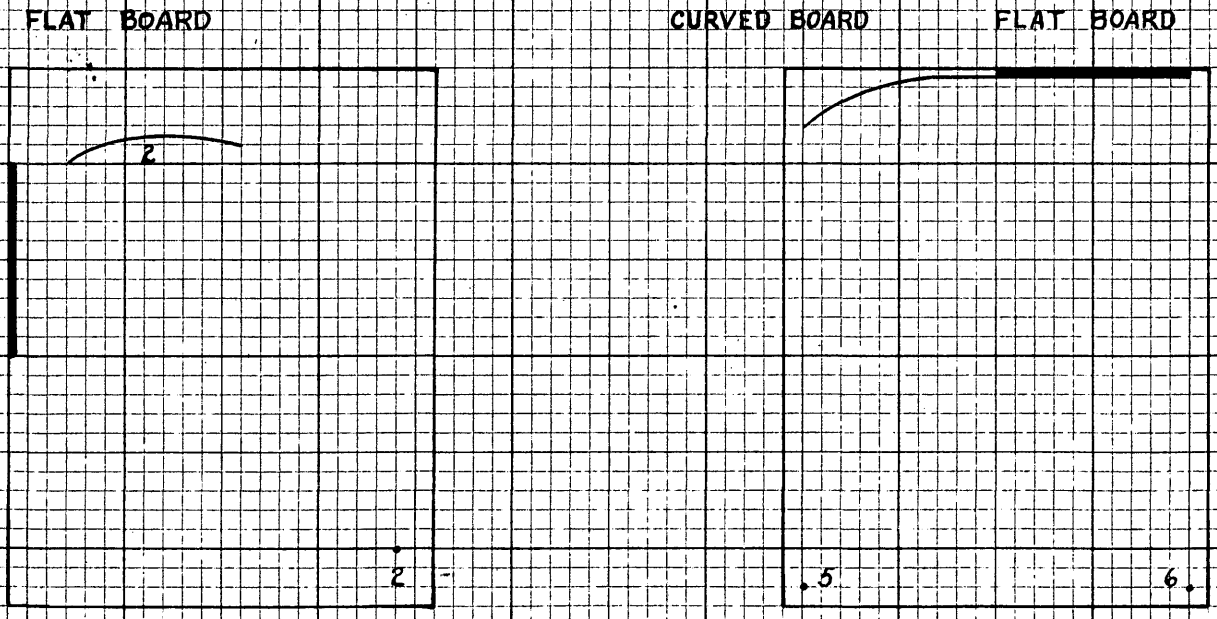
DIAGRAM OF MATERIAL PLACED UPON CHALKBOARDS AT WILLIAMSBURG.

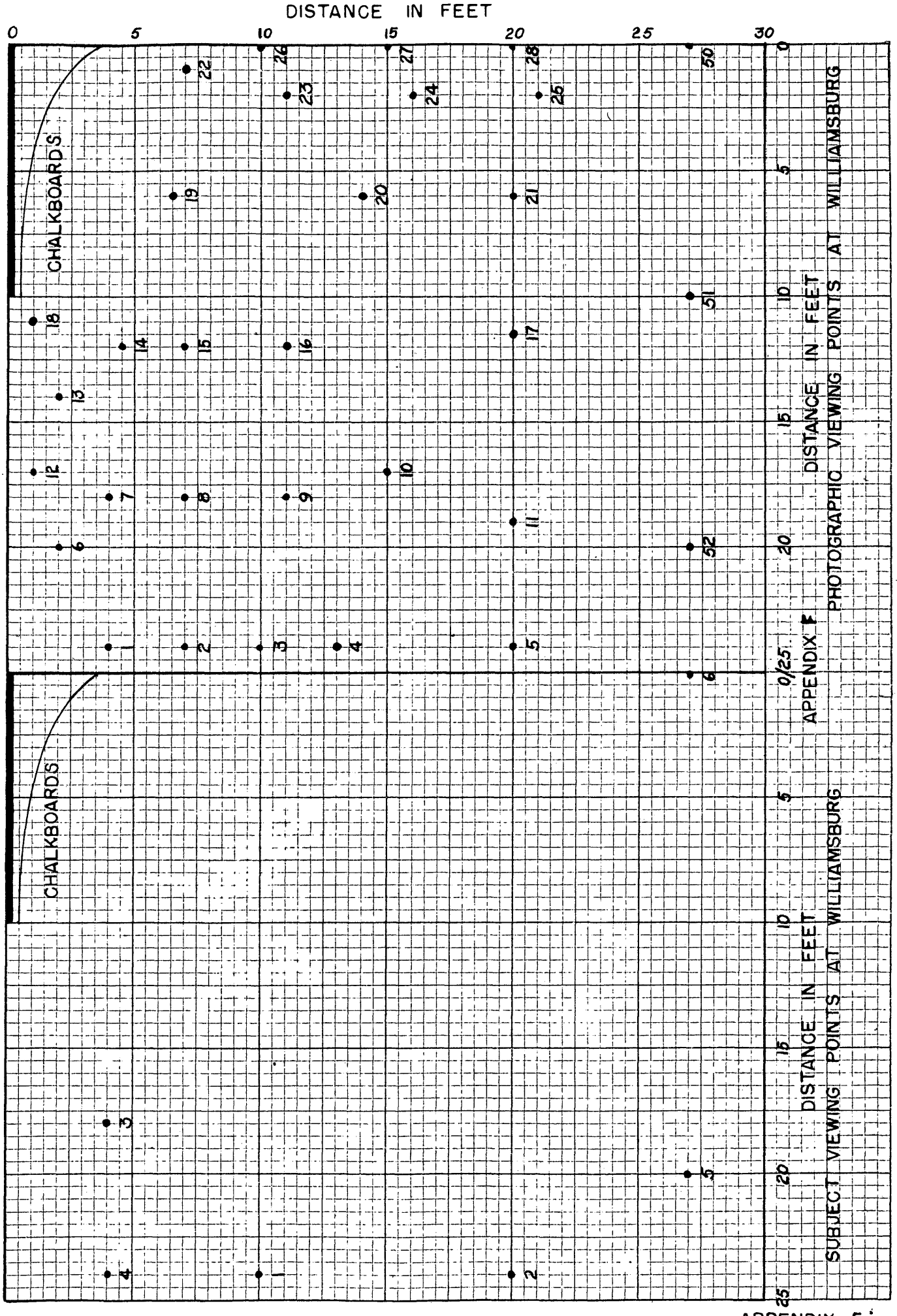


APPENDIX E

LOCATIONS OF CURVED BOARD WITH RESPECT TO FLAT BOARD AND VIEWING POINTS AT WILLIAMSBURG.



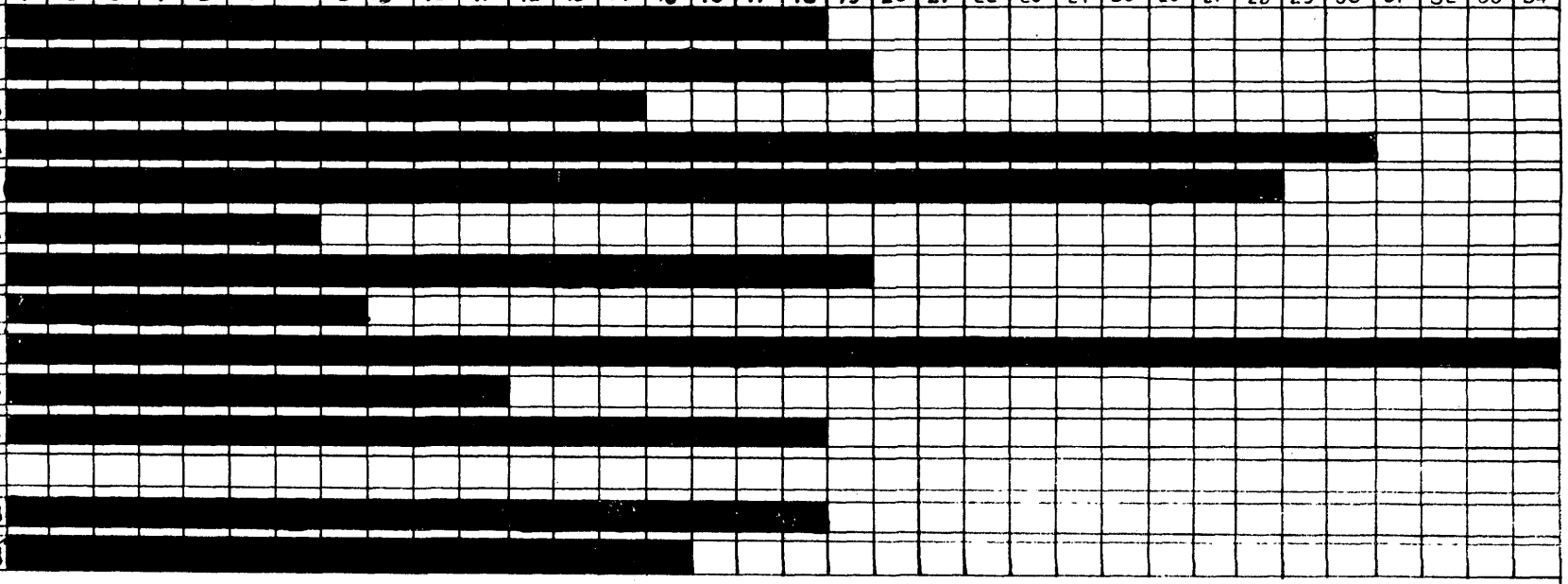



DISTANCE IN FEET
0
5
10
15
20
25
30
CHALKBOARDS
CHALKBOARDS
DISTANCE IN FEET
SUBJECT VIEWING POINTS AT WILLIAMSBURG
APPENDIX F
PHOTOGRAPHIC VIEWING POINTS AT WILLIAMSBURG
DISTANCE IN FEET
0/25

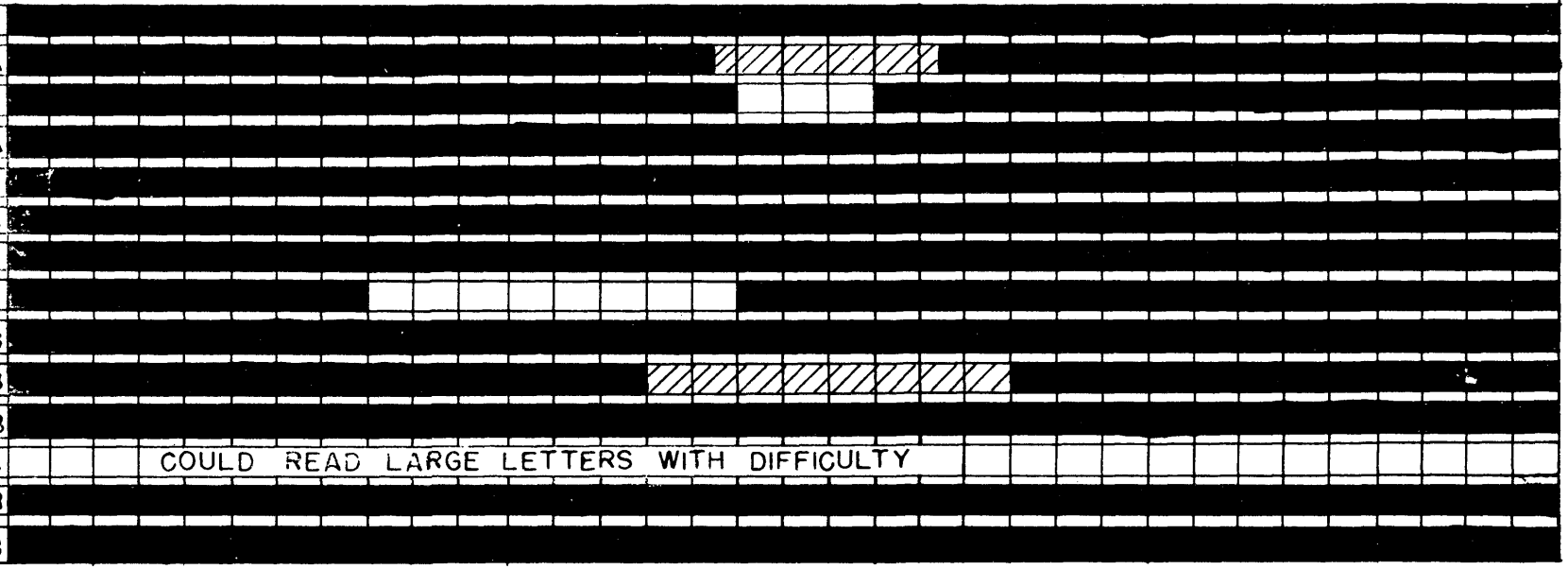
APPENDIX G

A–FIRST GROUP
B–SECOND GROUP

WILLIAMSBURG VIEWING POINT NO. 1 FLAT (READING CENTER LINE)



WILLIAMSBURG VIEWING POINT NO. 1 CURVED (READING CENTER LINE)

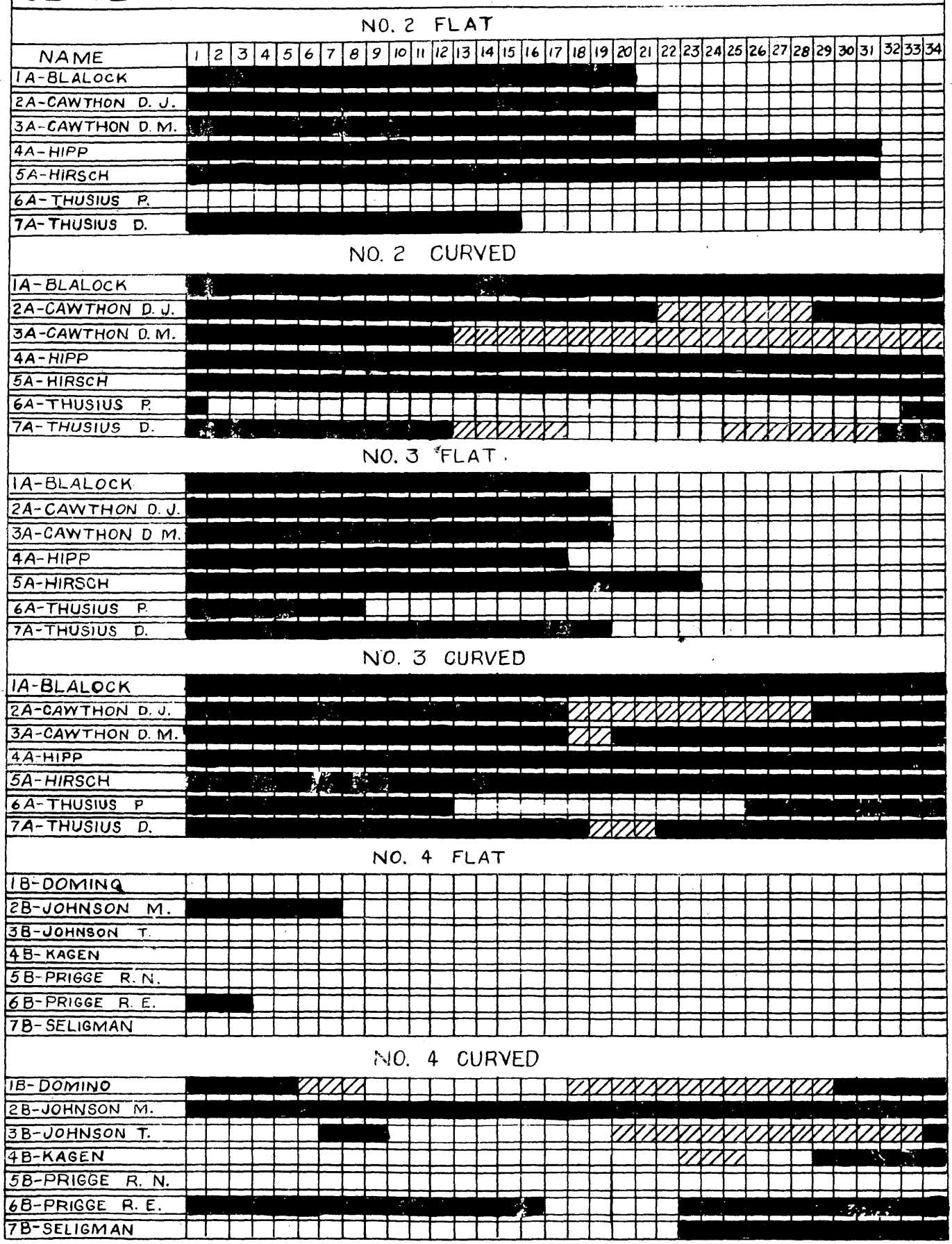


APPENDIX G

APPENDIX H

WILLIAMSBURG VIEWING POINTS NOS. 2, 3 & 4 READING CENTER LINE.

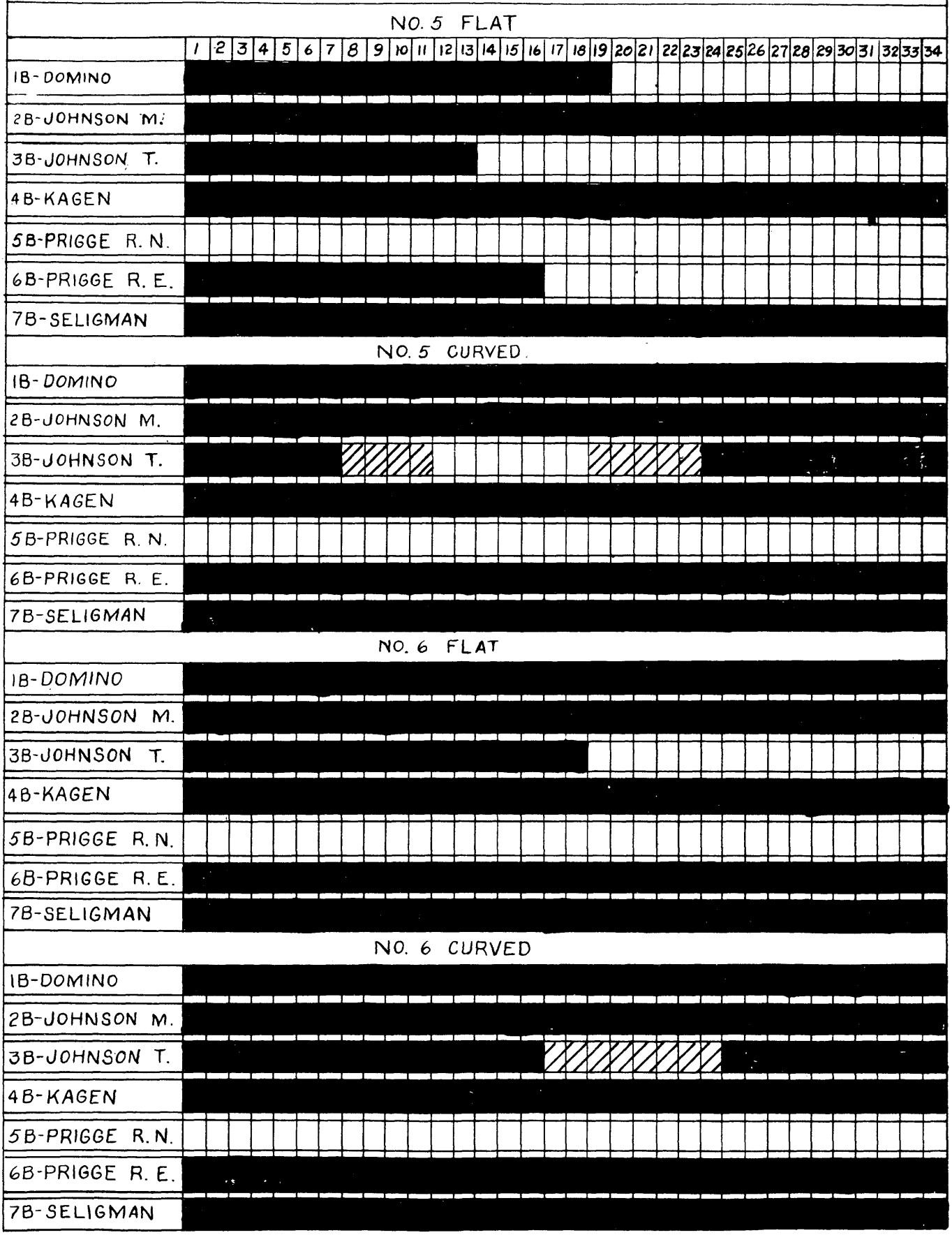
■ - COUNTABLE SECTION OF BOARD ▨ - DISTINGUISHABLE SECTION OF BOARD

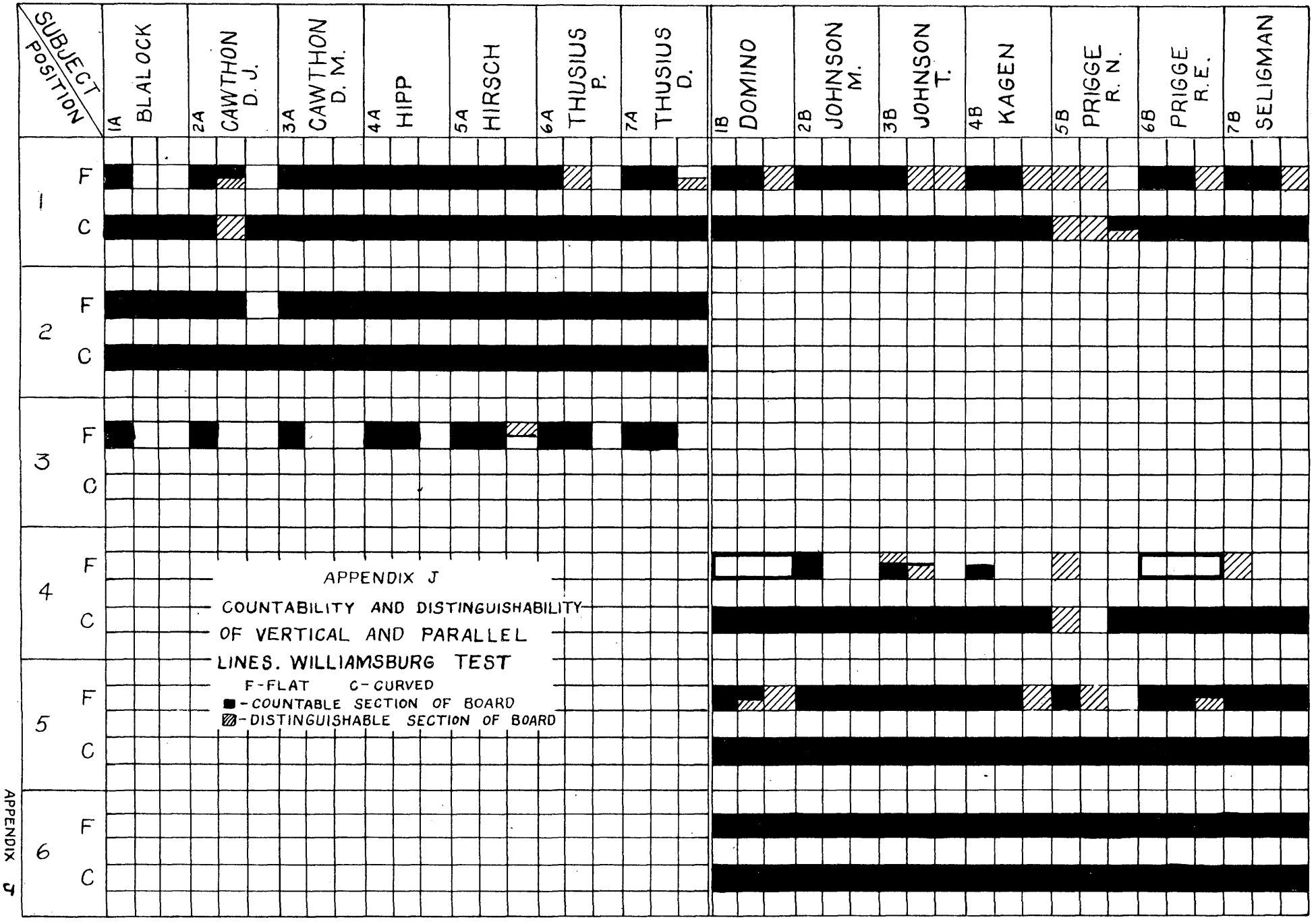


APPENDIX 1

WILLIAMSBURG VIEWING POINTS NOS. 5 & 6 READING CENTER LINE.

▒-COUNTABLE SECTION OF BOARD ▨-DISTINGUISHABLE SECTION OF BOARD




SUBJECT
POSITION
1A BLALOCK
2A CAWTHON D. J.
3A CAWTHON D. M.
4A HIPP
5A HIRSCH
6A THUSIUS P.
7A THUSIUS D.
1B DOMINO
2B JOHNSON M.
3B JOHNSON T.
4B KAGEN
5B PRIGGE R. N.
6B PRIGGE R. E.
7B SELIGMAN
1
2
3
4
5
6
F
C
APPENDIX J
COUNTABILITY AND DISTINGUISHABILITY
OF VERTICAL AND PARALLEL
LINES. WILLIAMSBURG TEST
F-FLAT C-CURVED
■-COUNTABLE SECTION OF BOARD
▨-DISTINGUISHABLE SECTION OF BOARD

COMMENTS OBTAINED FROM WILLIAMSBURG SUBJECTS

Group I

"The curved board was definitely easier to read. Figures were more easily distinguished and parallel lines were much easier to distinguish. Beginning and ending letters and figures in each group were most easily read. The section of the curved board, where the substantial curve began, was the most difficult portion of the curved board to read, but this section of the curved board was more easily read than the second quarter of the straight blackboard."

1a

"I could see the letters, lines, and figures on the far end much better on the curved board than on the straight board."

"The figures on the curved board in the middle were not so clear--on a whole I thought the curved board was clearer."

2a

"My impressions were that the curved blackboard, from certain positions, was much easier to see than the straight one. I think the lighting was constant and glare approximately the same on both boards."

3a

"I can't see the over-all objective of the test; however, the test may show how various eyes react under different conditions. I sincerely think I could read all the letters and numbers on the curved board. I think a more positive test could be obtained by using uniform letters."

4a

"In all three positions, I found it easier to distinguish letters, breaks in circles, etc., on the curved board. Many times I could apparently give the correct answer for the flat board, when actually, I was not too sure of myself."

5a

"(1) Much easier to read letters and figures on the curved board. Last position of reader gave best visibility of both boards. For me the small row of letters was too small to distinguish to be a good test; also, the two middle letters were crowded together."

6a

"Could you be experimenting with the possibilities of cinemascope type blackboards? I think there are definite possibilities. How about script on the curved areas? Is it difficult for the teacher or student to write on a curve? Do the words and letters bunch up and make reading difficult from distance?"

7a

Group II

"The tests were very thorough. Having always had good vision and no trouble reading on a blackboard the curved board is still a definite relief and more restful. I would highly recommend the curved board for schools."

1b

"I think for a better survey should use some children too--. Would like a test in daylight to see the glare on the flat vs. curved board. Should try sitting in desk position. I thought the curved board much easier to read at point No. 1 (more noticeable). Could read much better from right corner of room at point No. 6 than from the left at point No. 5. Would like for curiosity to have a flash test--i.e., only look at board for a second for identification like the student whose eyes are constantly up and down from desk to board and adjusting quickly. Most interesting."

2b

"At point No. 4 I believe that the close end of the home-made chalkboard was slightly warped, thus making it difficult to distinguish some of the small letters."

"It might have been more accurate if the board had been washed after each erasure. The chalk smear made it hard to tell the "o'clock" of the openings in the circles. Also, it seemed as if some of the openings were larger than others."

3b

(From point No. 1) "After reading from both boards, I concluded that it was generally easier to read from the curved board. At this point I decided that the purpose of the test was to prove the over-all efficiency of the curved board."

(From point No. 4) "I felt that I was doing a lot of guessing. Nevertheless, it did seem easier to read from the curved board, especially when it came to distinguishing separate lines. In reading the small letters, at times, I thought I could read a group—but after reading the first letter in the group I couldn't determine the other three."

(From points No. 5 and 6) "I had the same feeling in reading letter groups as I did at point No. 4. In moving from one chair to the other I remembered some answers given from the first chairs. This was especially true as regards the circles. I believe I was influenced to some degree by this, and it affected my answers from the second chair."

4b

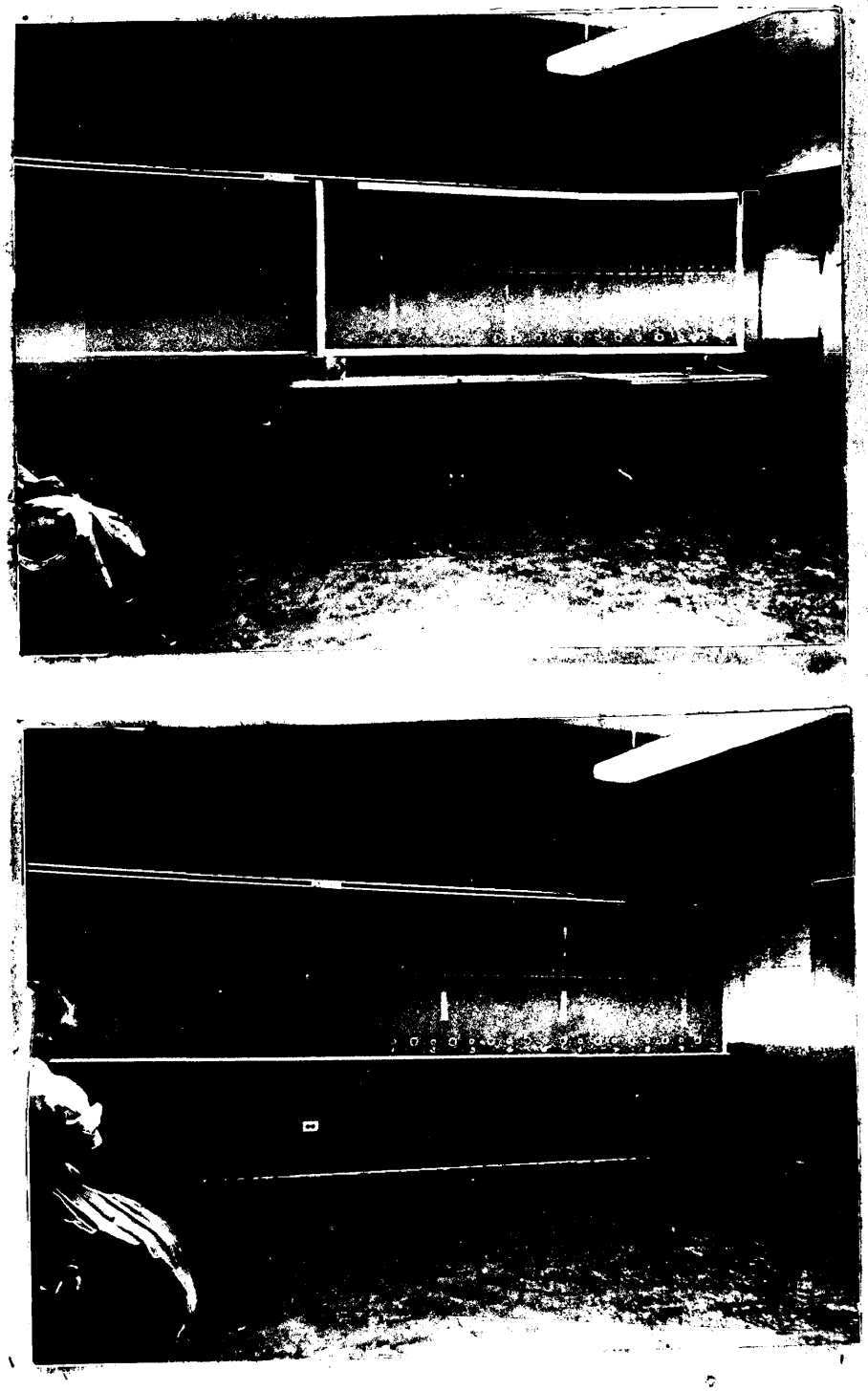
NOTE: No written comments were received from subject 5b.

"A lot of the difficulty for me in seeing spaces on the circles had to do with the smudges on the board and the variations in thickness of the chalk line. Also—being at the end of the day, my eyes became very tired and it became difficult to focus so constantly."

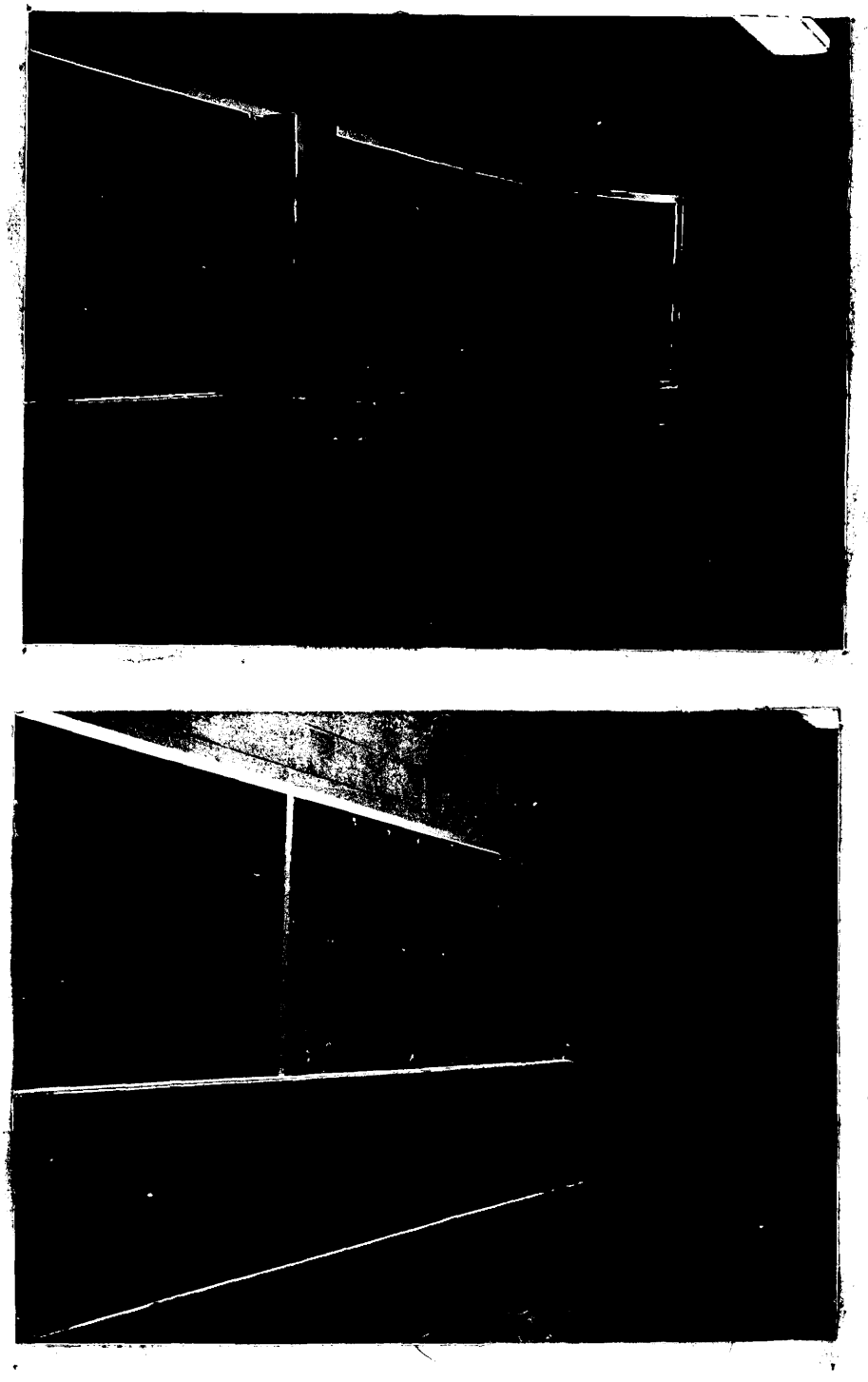
6b

"I generally was able to see numbers, figures, letters, etc., better on the curved board than on the flat board. There was a tendency also to remember some of the numbers and positions of breaks during the first two sessions. During the third session my eyes were a little tired and I had a headache."

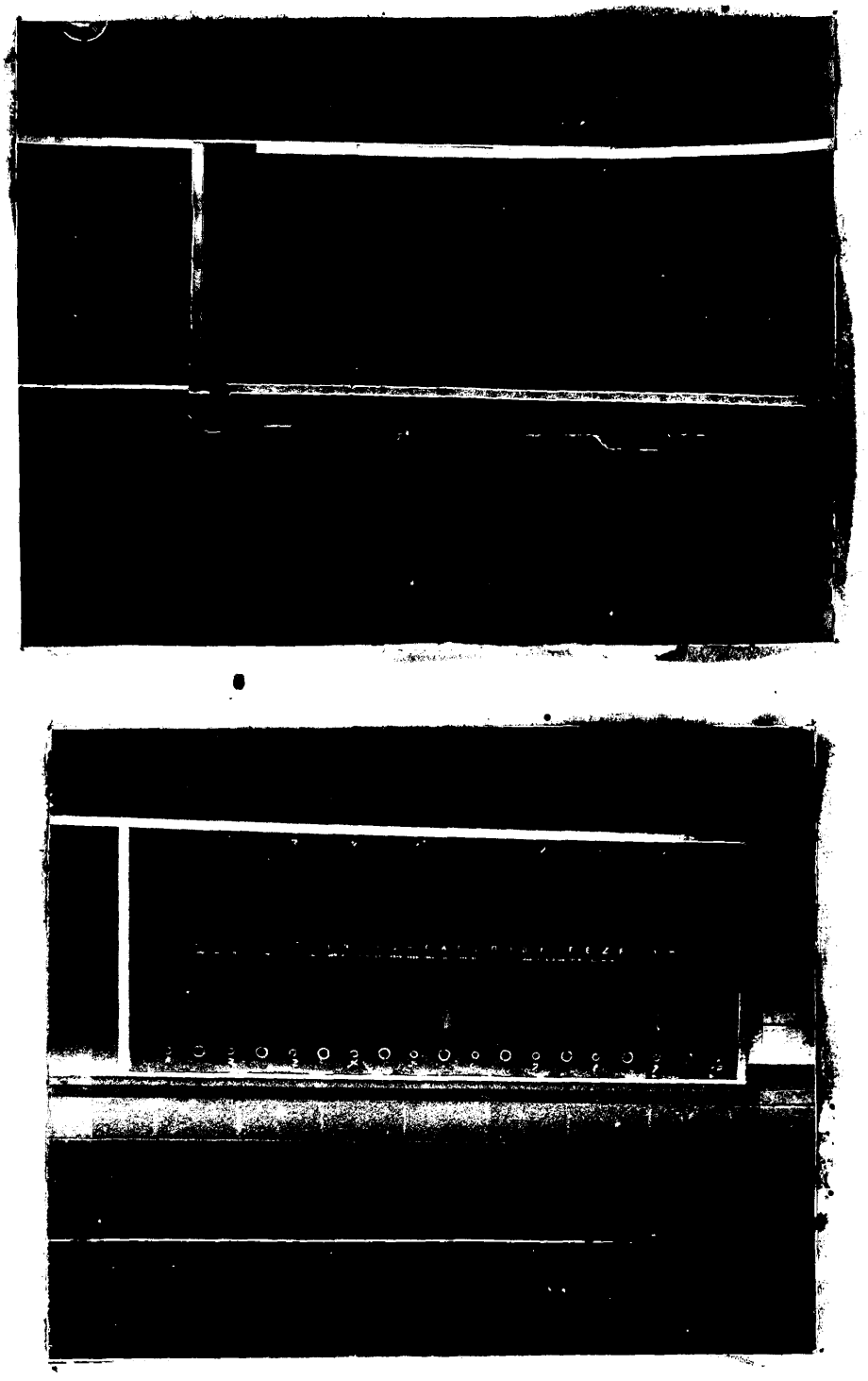
7b



CURVED AND FLAT BOARDS FROM PHOTOGRAPHIC VIEWING POINT NUMBER



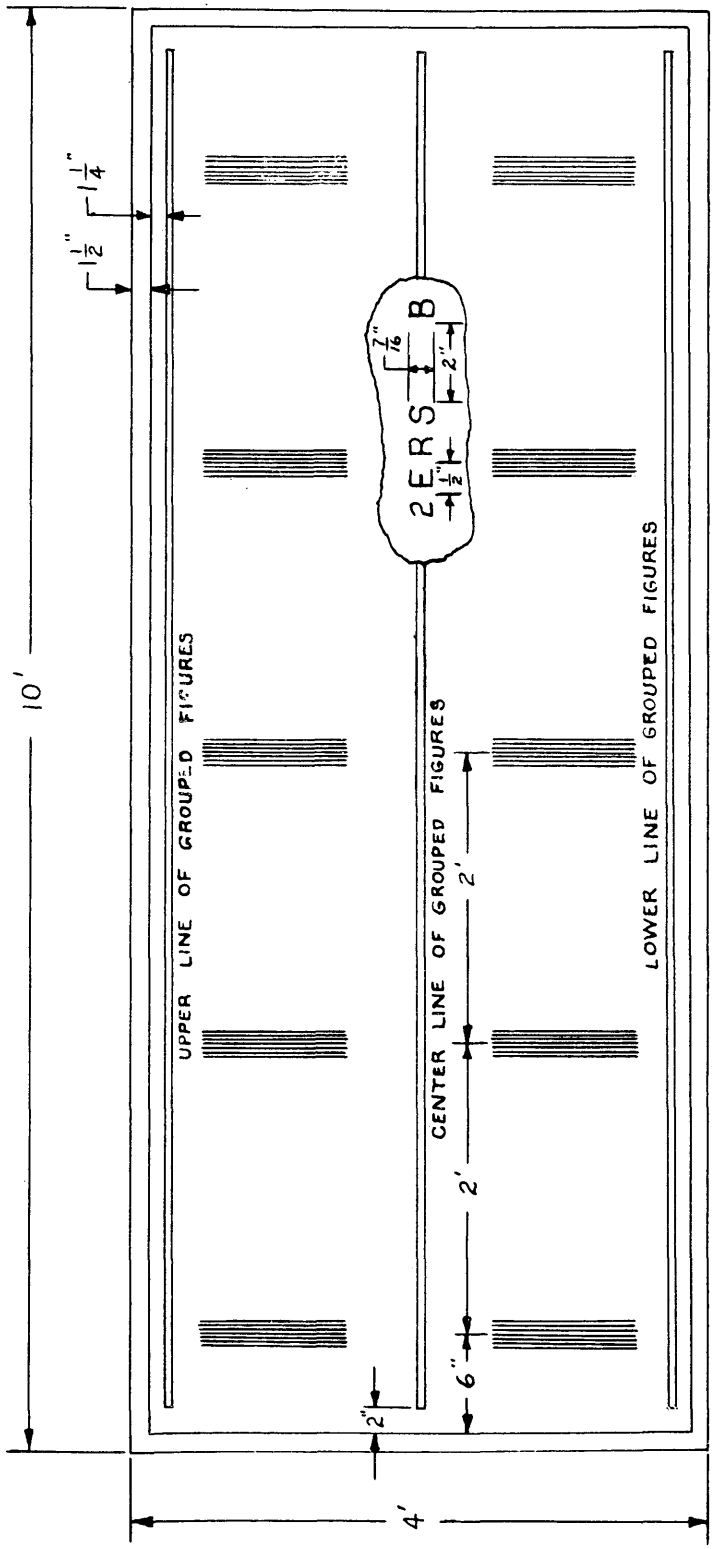
CURVED AND FLAT BOARDS FROM PHOTOGRAPHIC VIEWING POINT NUMBER



CURVED AND FLAT BOARDS FROM PHOTOGRAPHIC VIEWING POINT NUMBER

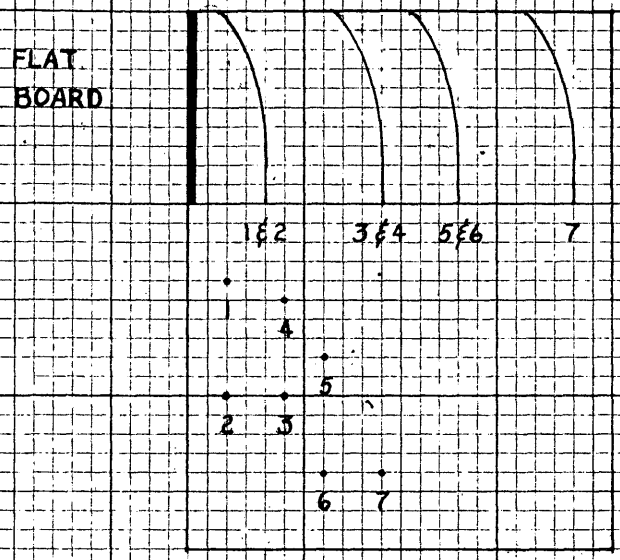
APPENDIX M

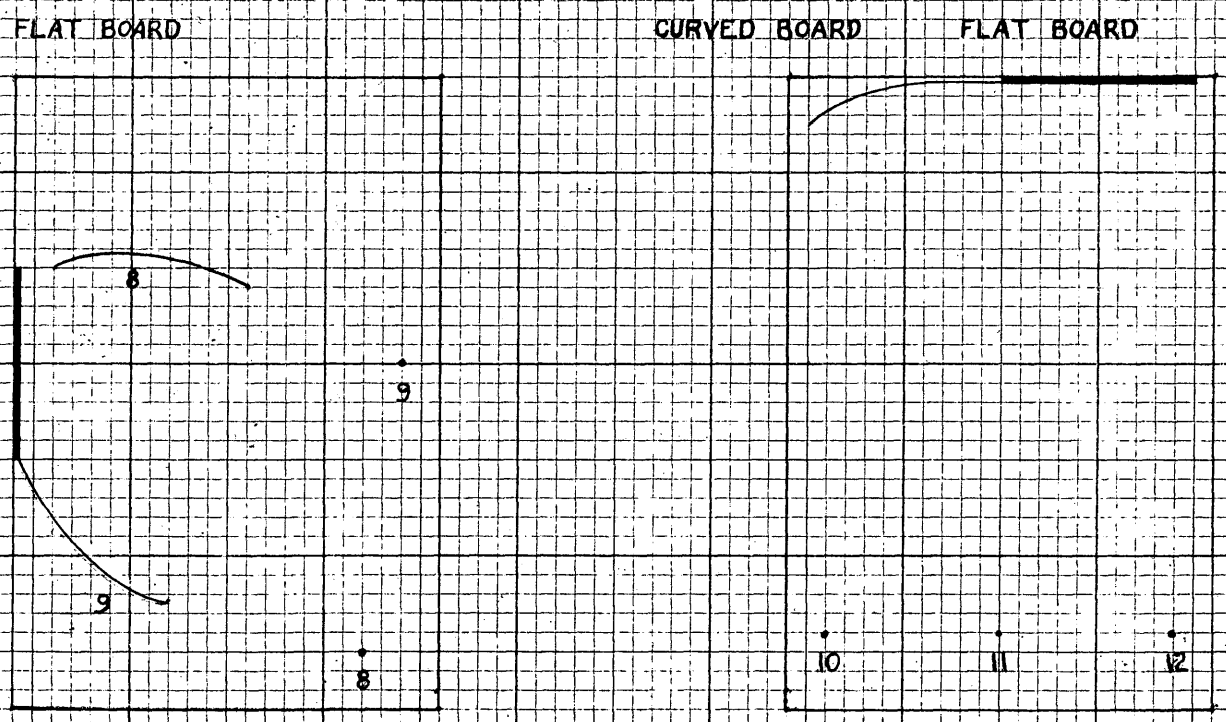
DIAGRAM OF MATERIAL PLACED UPON CHALKBOARDS AT CRADOCK.



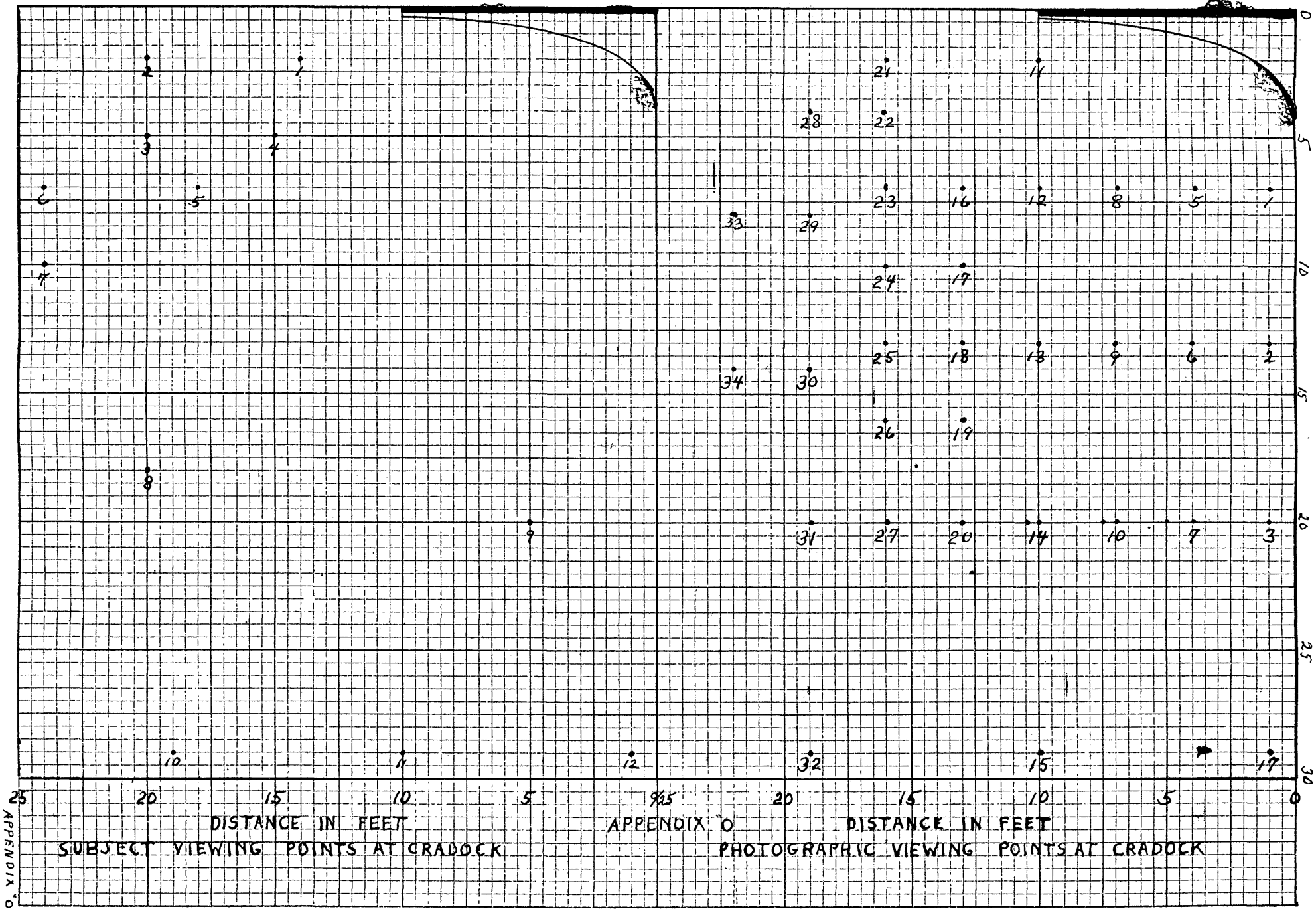
APPENDIX N

LOCATIONS OF CURVED BOARD WITH RESPECT TO FLAT BOARD AND VIEWING POINTS AT CRADOCK.



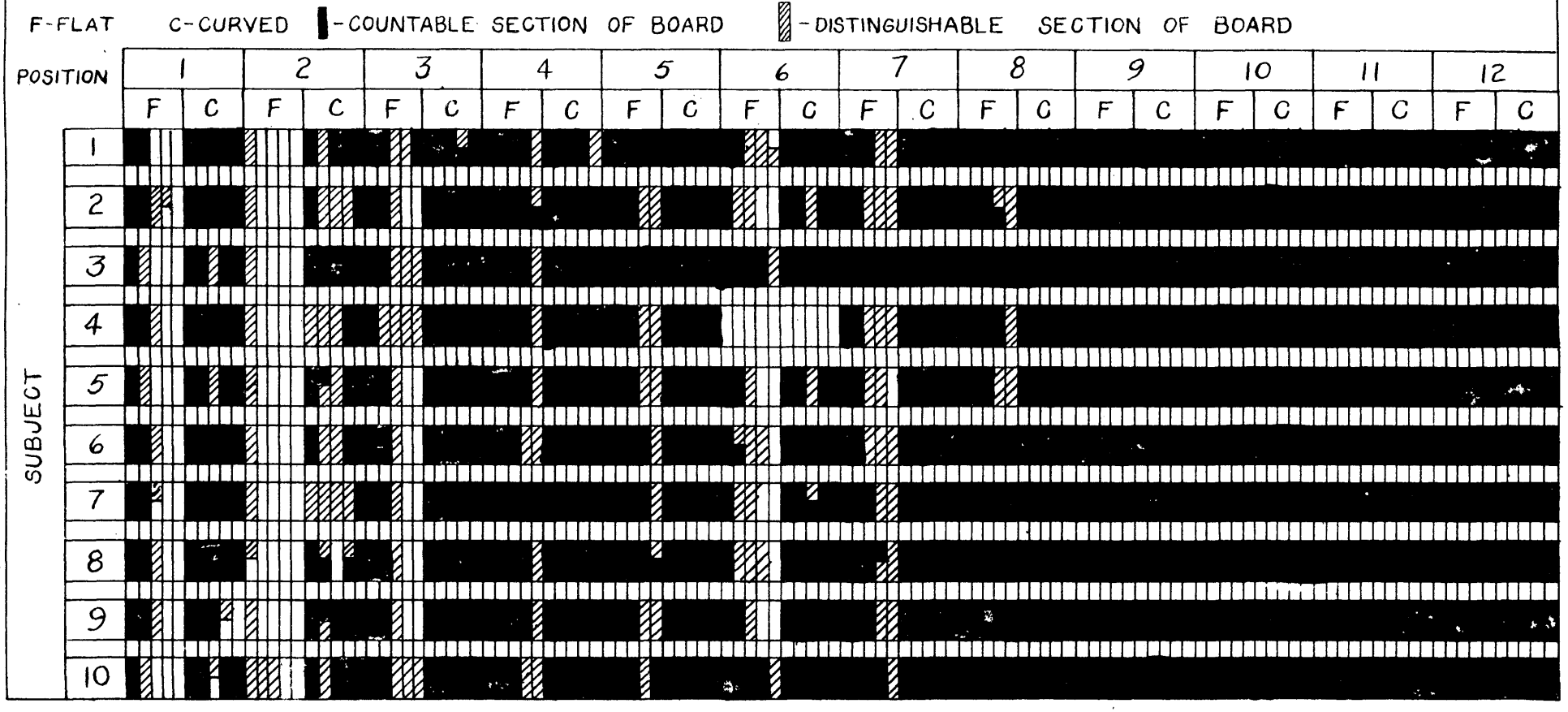


SAME CURVED LOCATION FOR ALL THREE POINTS.


DISTANCE IN FEET
0
5
10
15
20
25
30
25 20 15 10 5 0
DISTANCE IN FEET
APPENDIX "O"
SUBJECT VIEWING POINTS AT CRADOCK
APPENDIX "O"
PHOTOGRAPHIC VIEWING POINTS AT CRADOCK
25 20 15 10 5 0
DISTANCE IN FEET

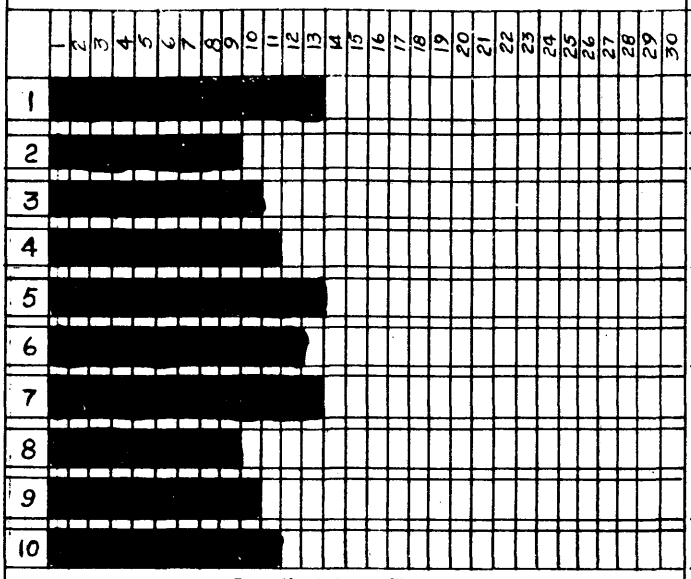
APPENDIX P

COUNTABLE AND DISTINGUISHABLE SETS OF PARALLEL LINES. AT ALL SUBJECT VIEWING POINTS. CRADOCK TEST.

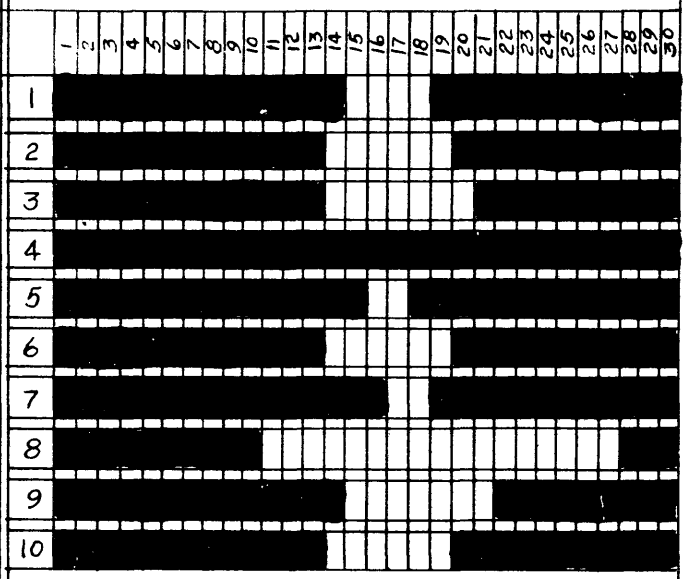


APPENDIX Q
CRADOCK VIEWING POINT NO. 1

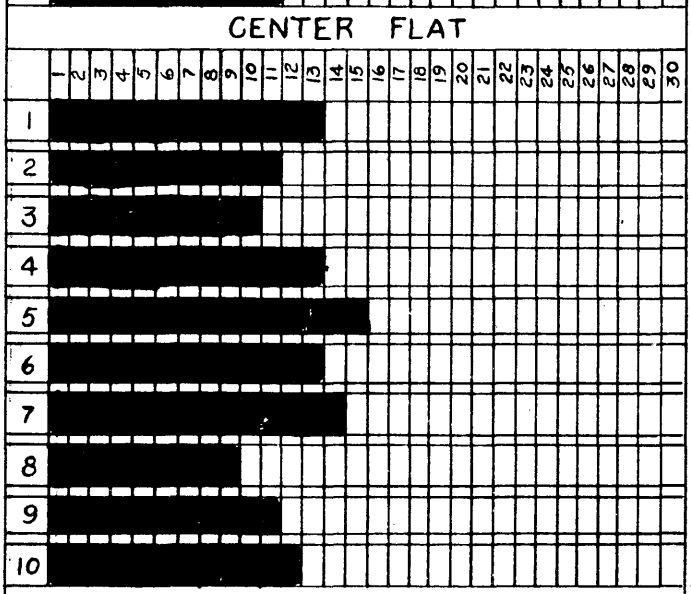
TOP FLAT



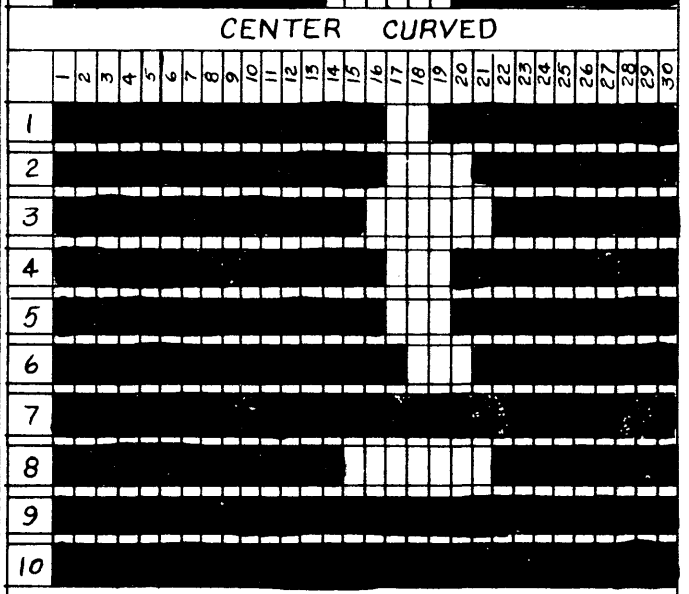
TOP CURVED



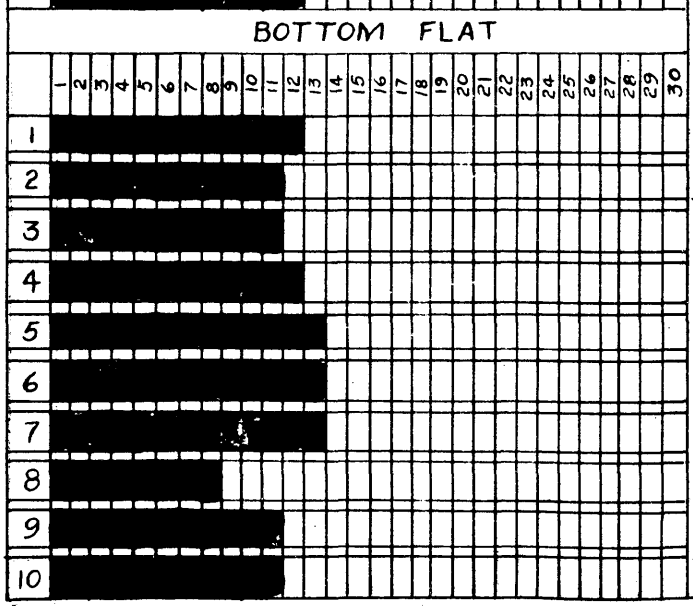
CENTER FLAT



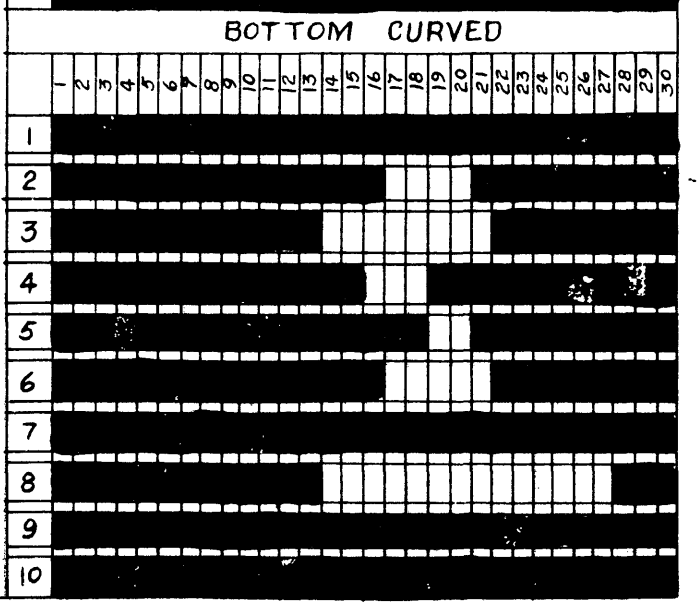
CENTER CURVED



BOTTOM FLAT

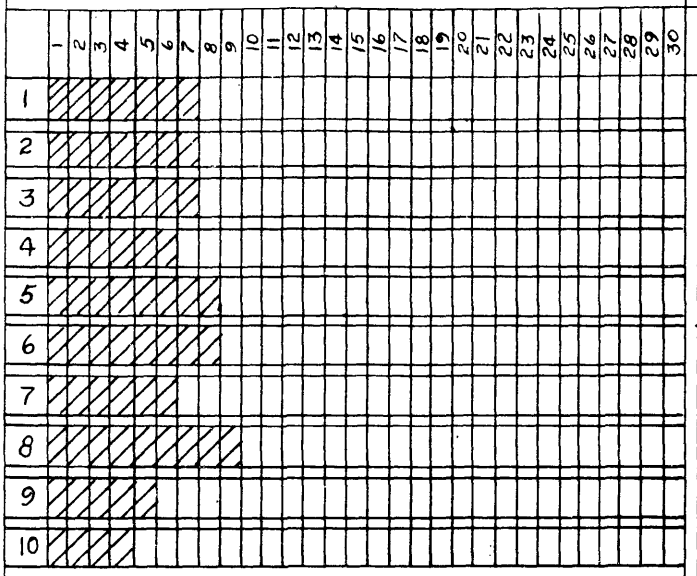


BOTTOM CURVED

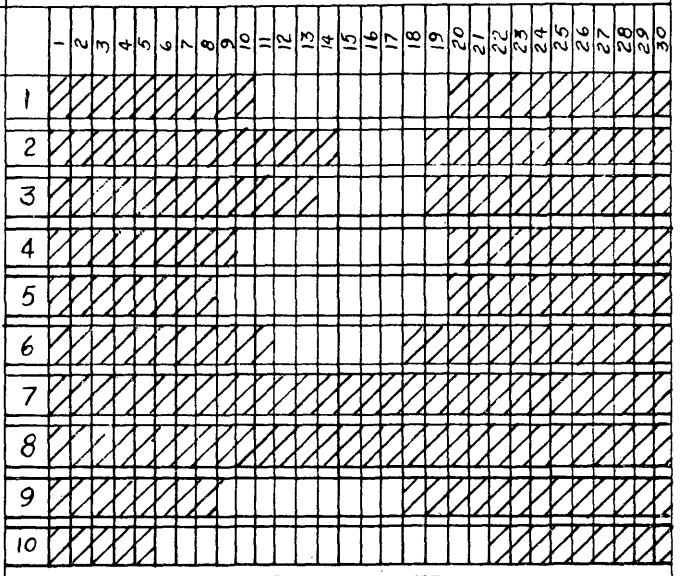


APPENDIX R
CRADOCK VIEWING POINT NO. 2

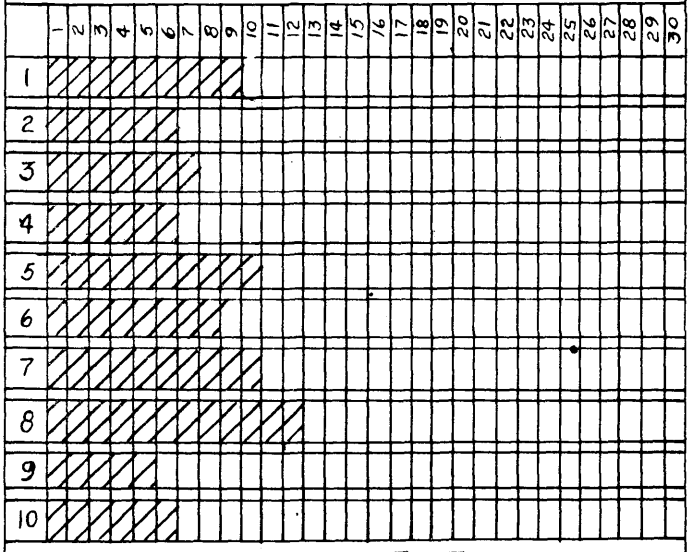
TOP FLAT



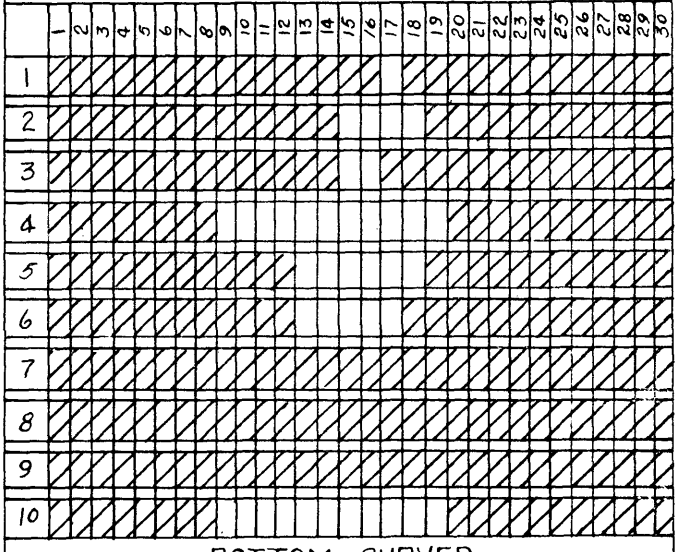
TOP CURVED



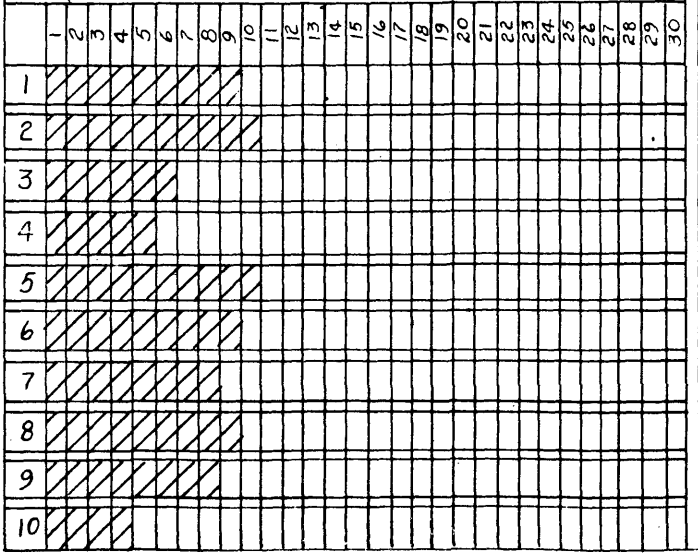
CENTER FLAT



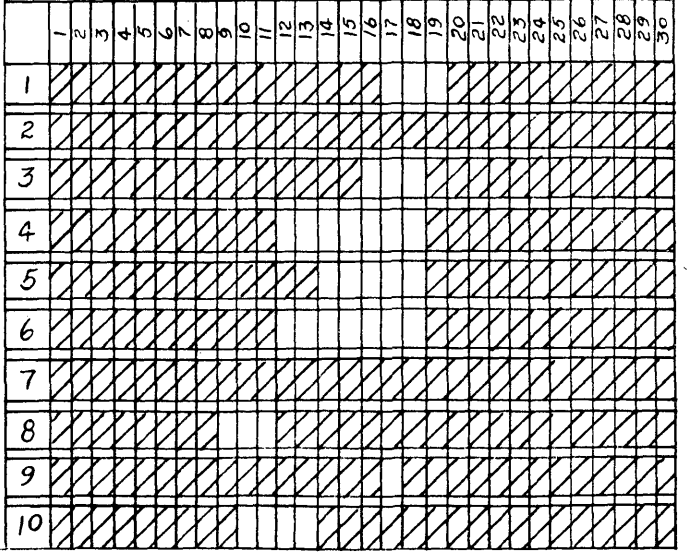
CENTER CURVED



BOTTOM FLAT



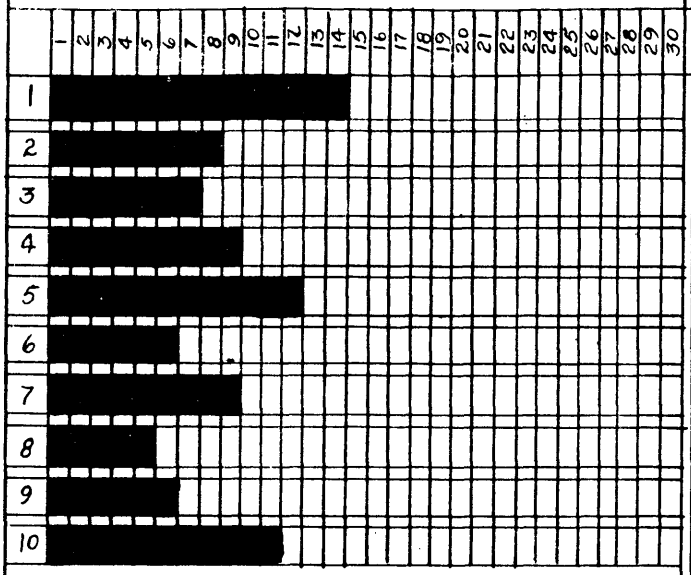
BOTTOM CURVED



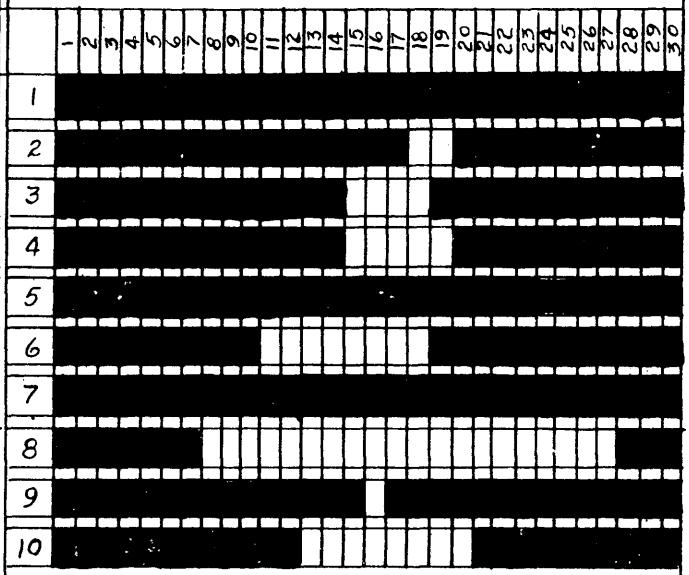
▨-DISTINGUISHABLE ONLY

APPENDIX S
CRADOCK VIEWING POINT NO. 3

TOP FLAT



TOP CURVED



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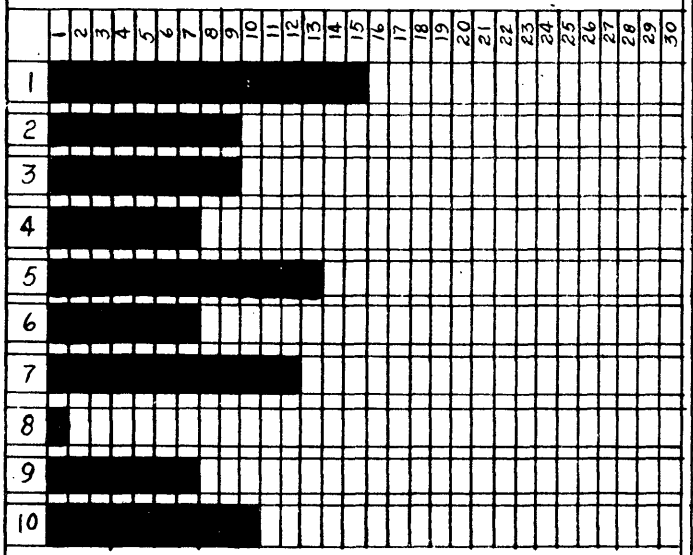

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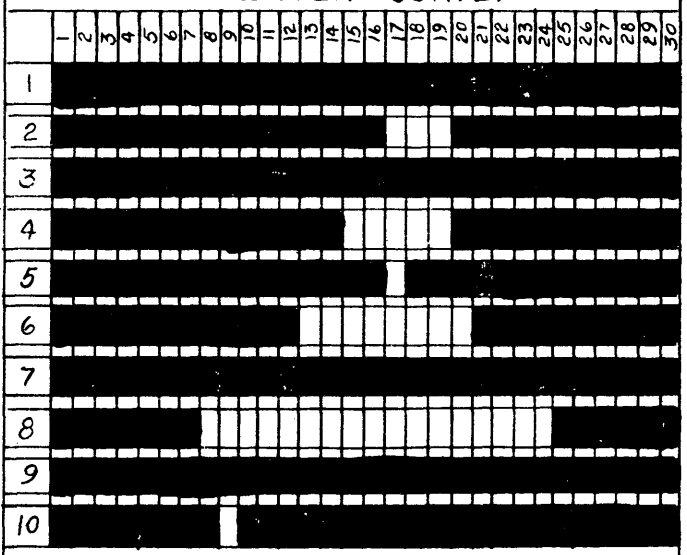
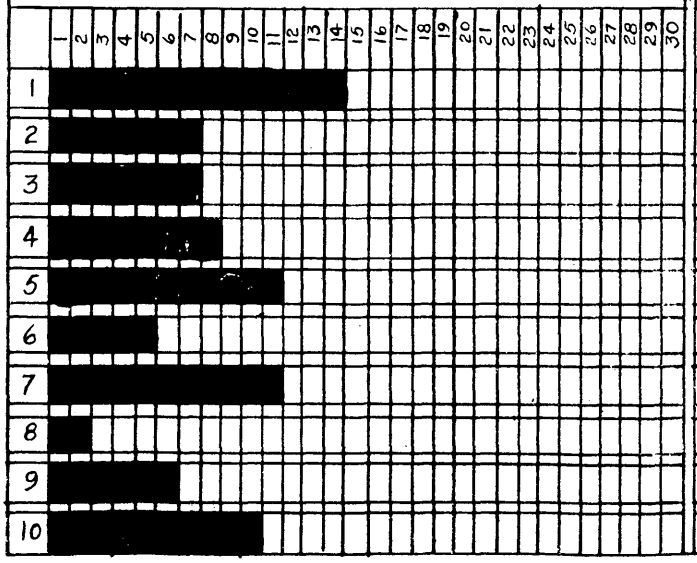


BOTTOM FLAT



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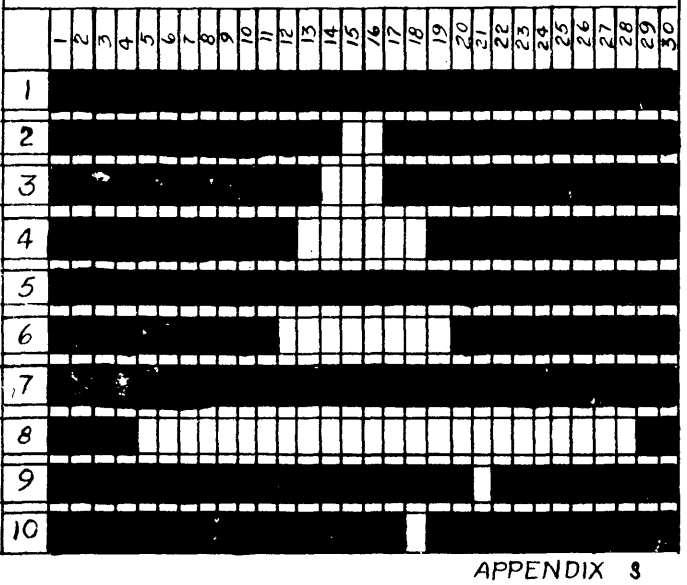
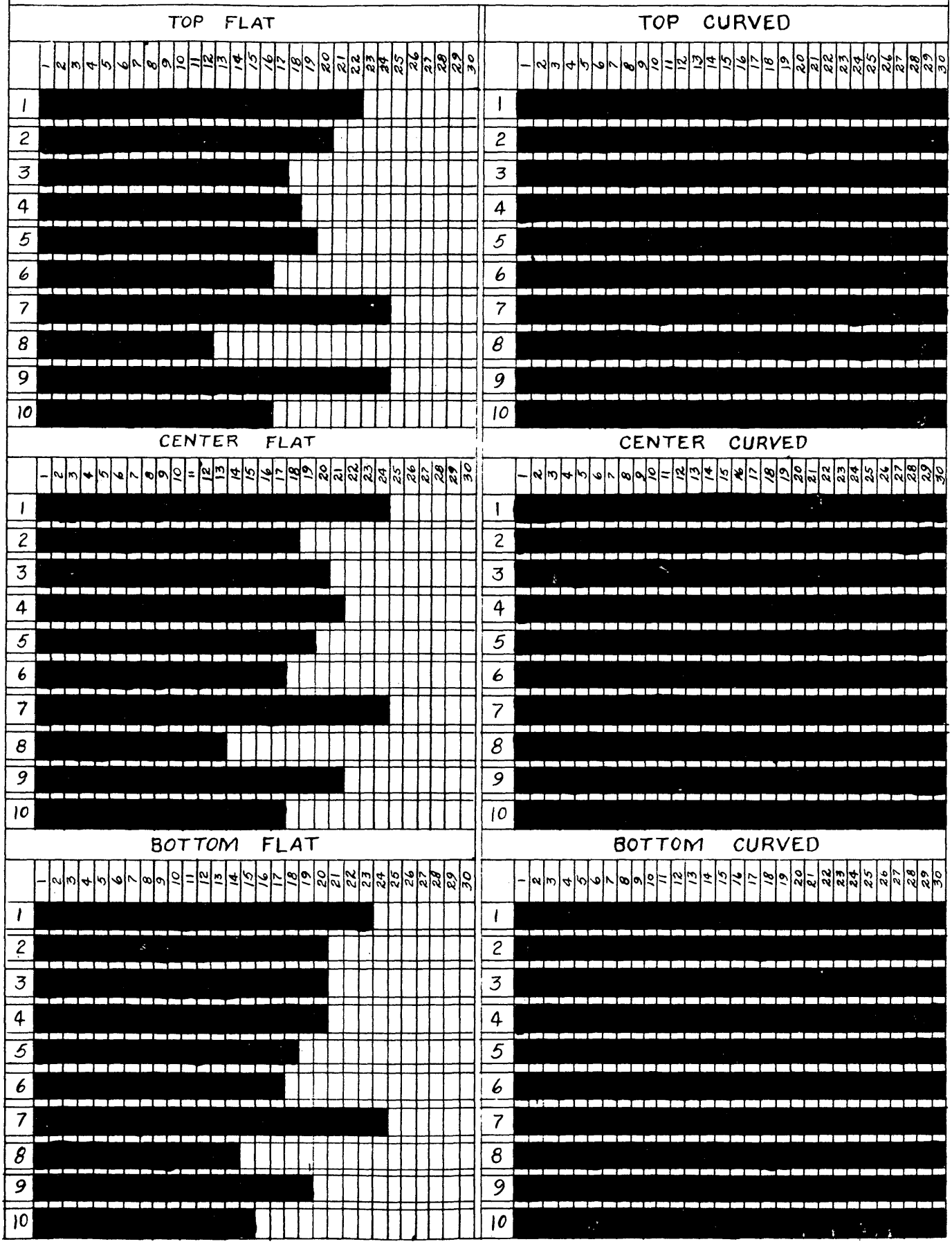
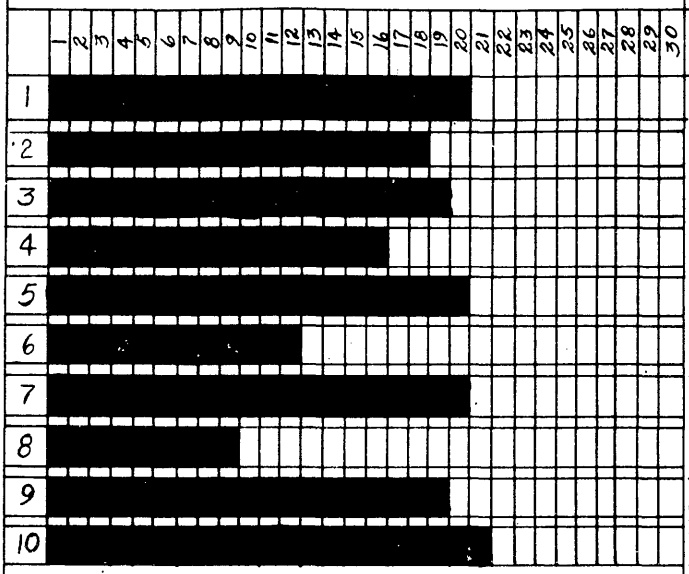


APPENDIX T
CRADOCK VIEWING POINT NO. 4

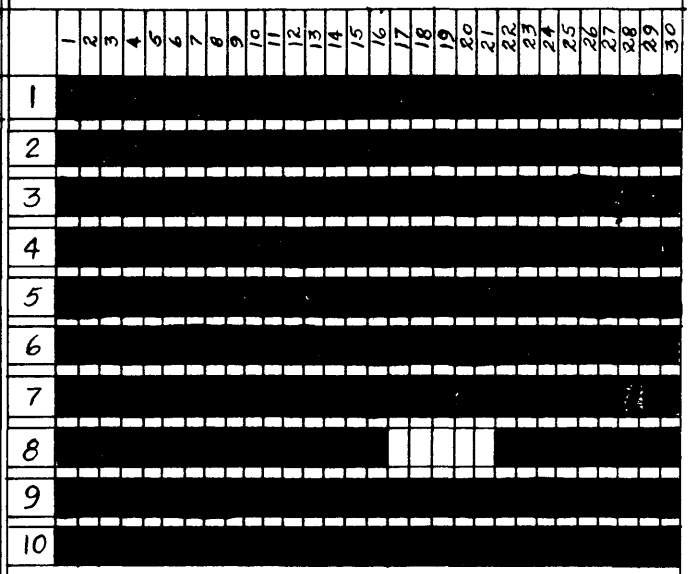


APPENDIX U
CRADOCK VIEWING POINT NO. 5

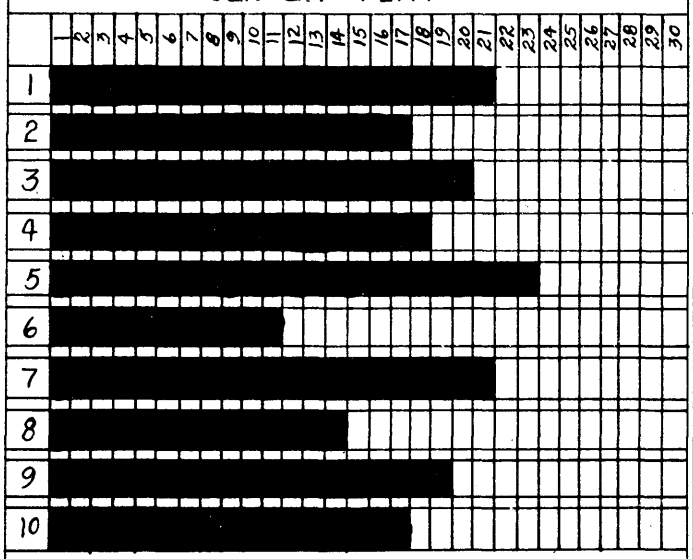
TOP FLAT



TOP CURVED



CENTER FLAT



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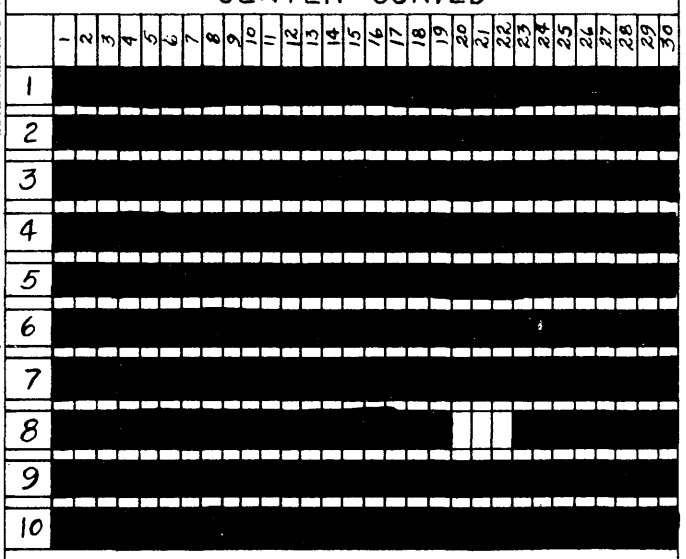

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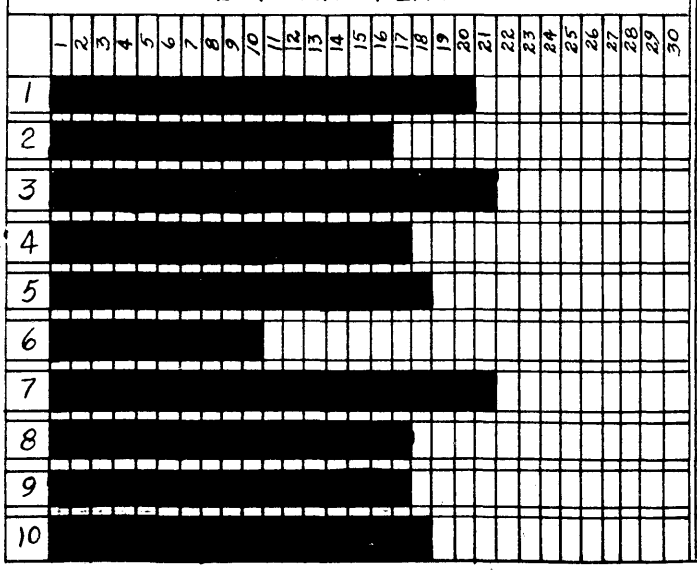
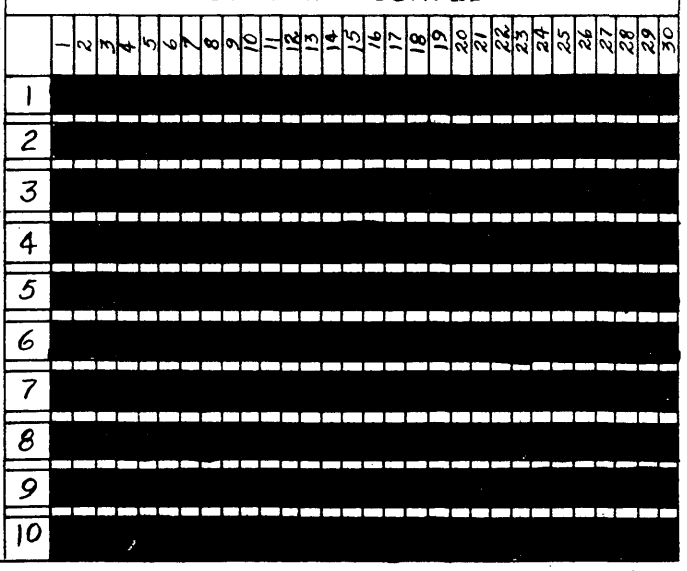


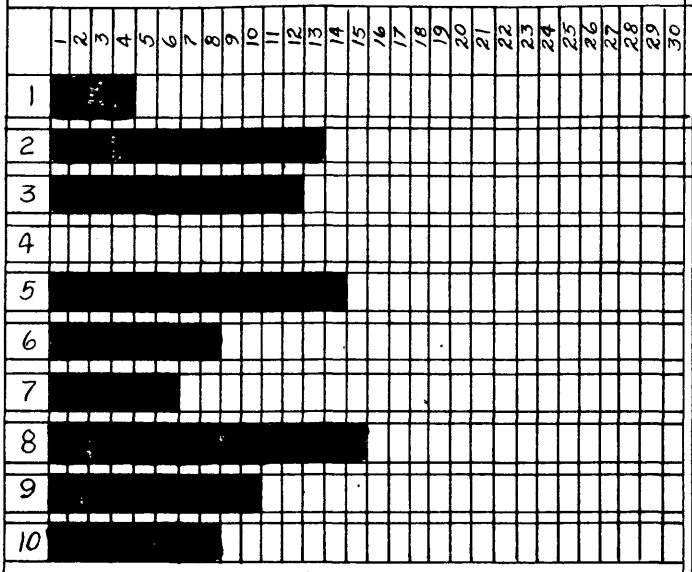
BOTTOM CURVED



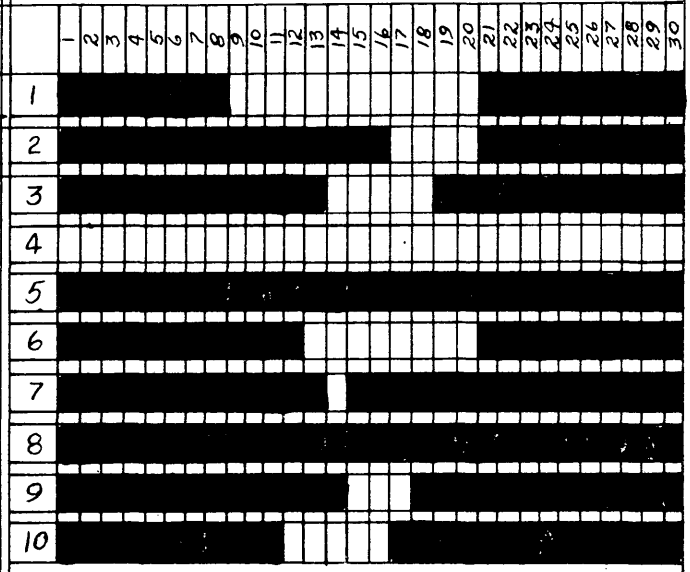
APPENDIX V

CRADOCK VIEWING POINT NO. 6

TOP FLAT



TOP CURVED



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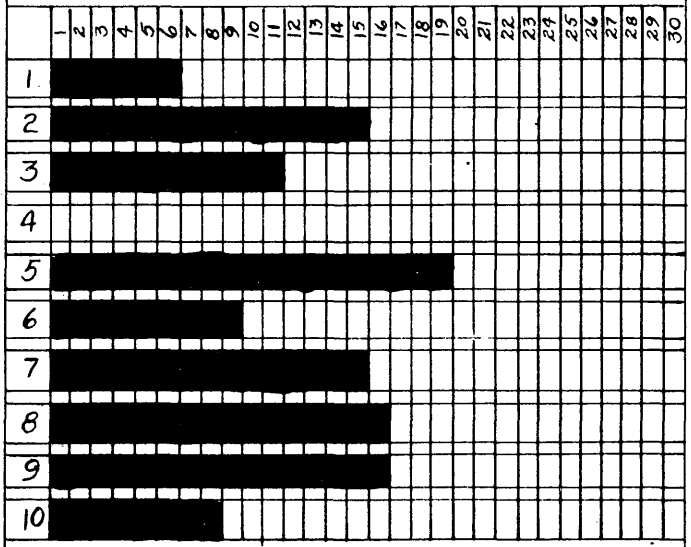

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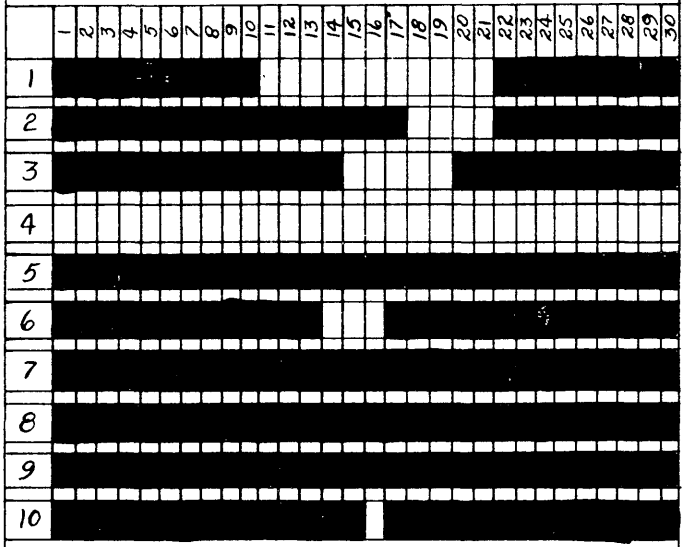
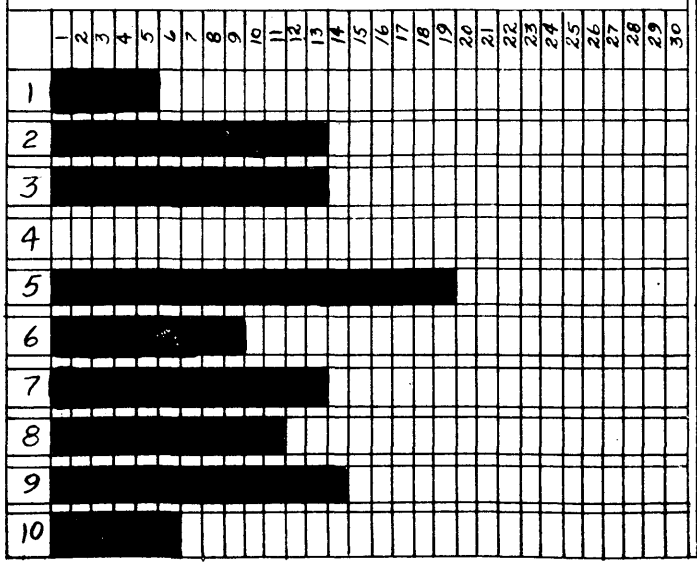
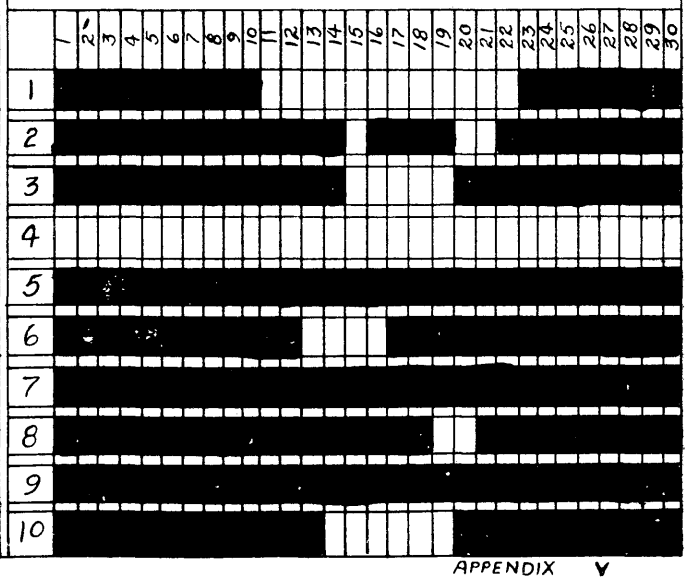


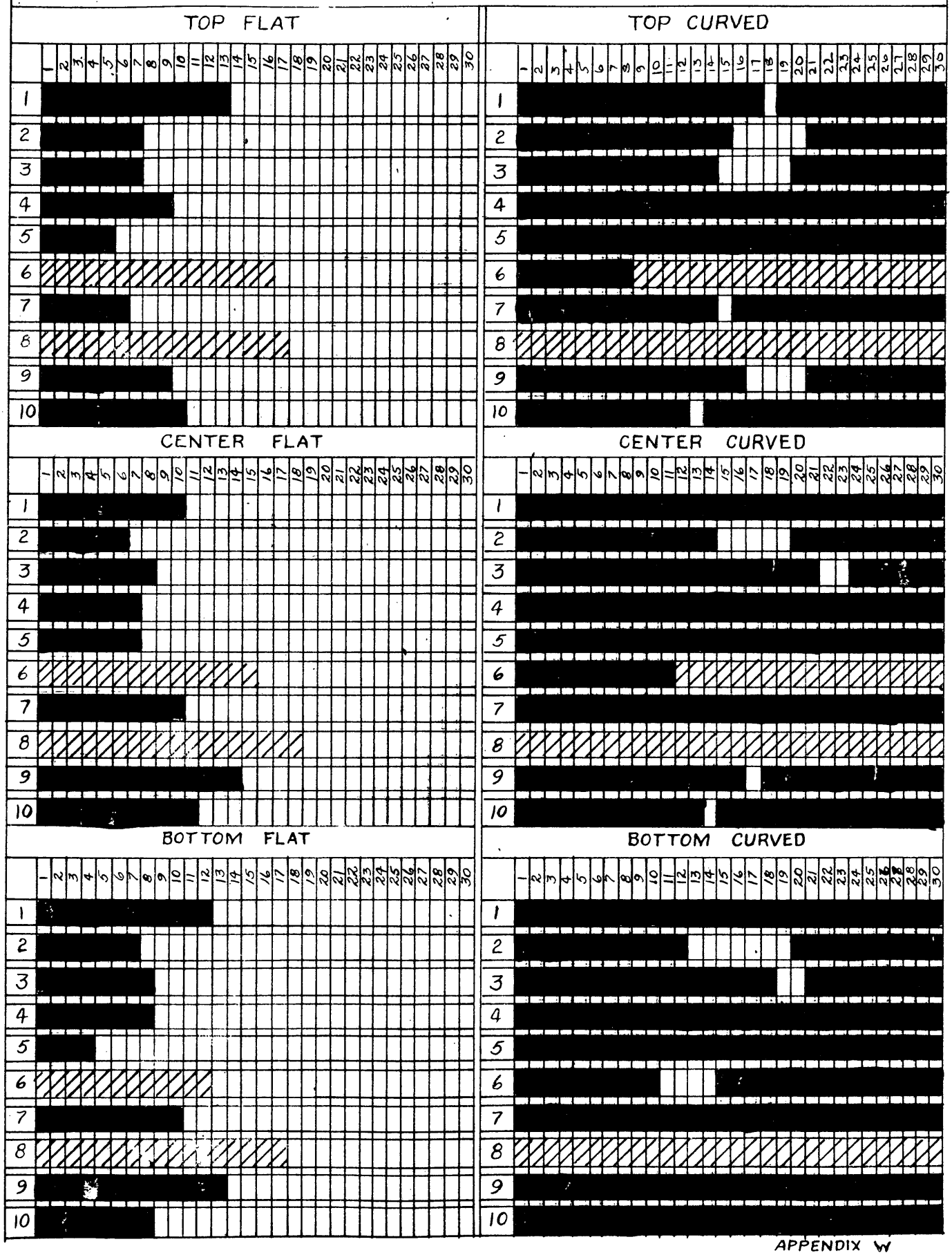
BOTTOM FLAT



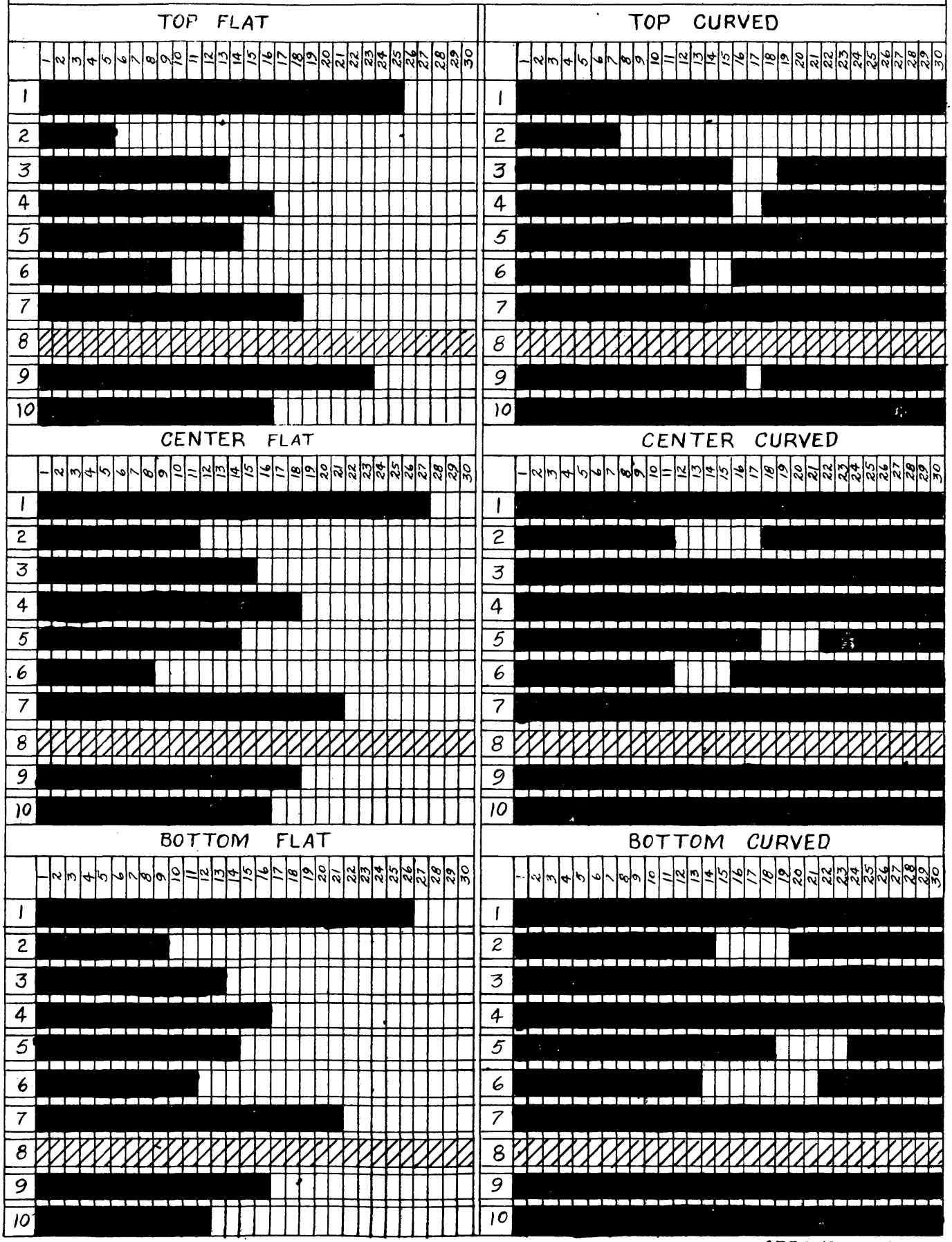
BOTTOM CURVED



APPENDIX W
CRADOCK VIEWING POINT NO. 7

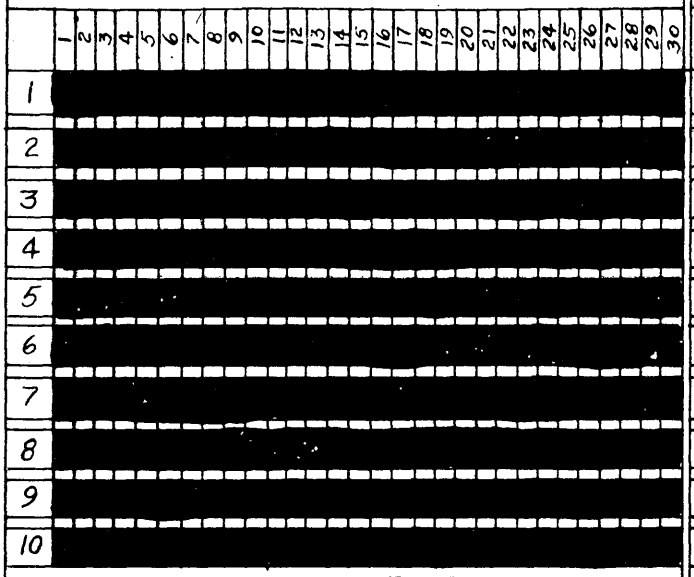


APPENDIX X
CRADOCK VIEWING POINT NO. 8

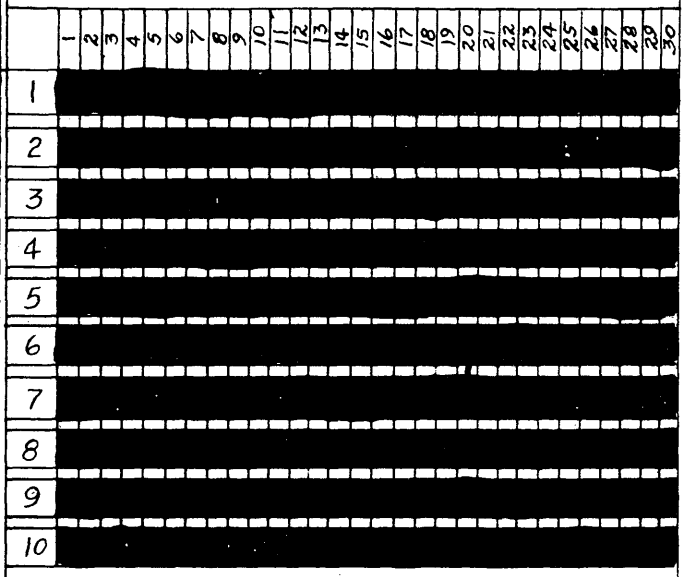


APPENDIX Y
CRADOCK VIEWING POINT NO. 9

TOP FLAT



TOP CURVED



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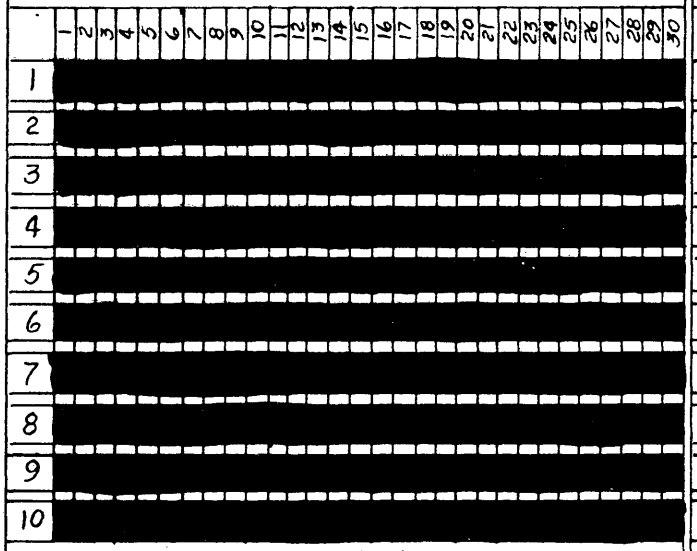
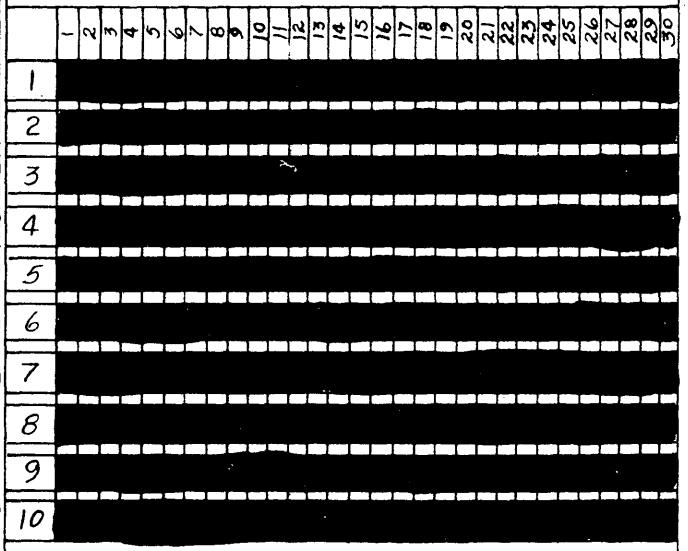
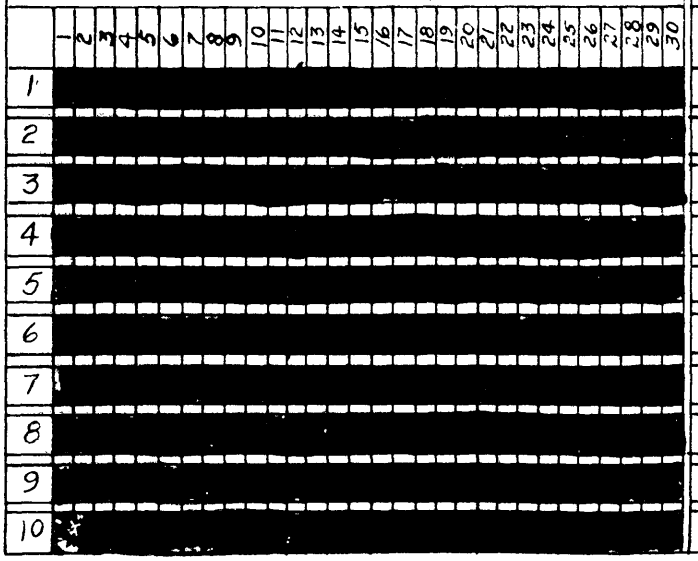


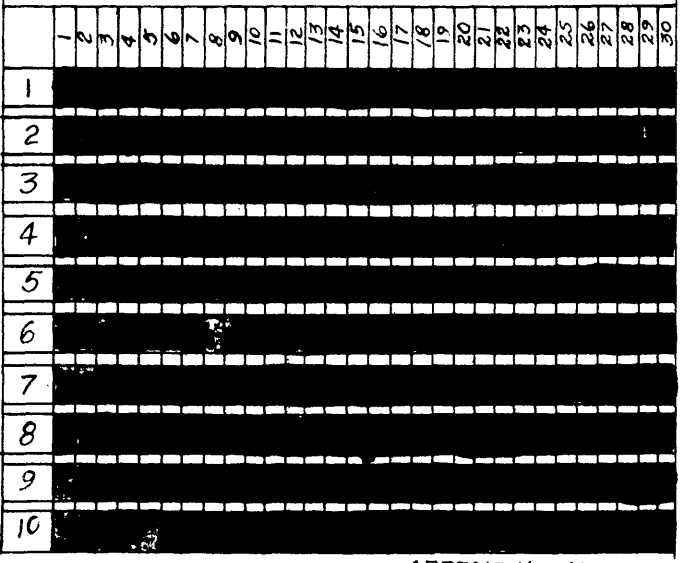
CENTER CURVED



BOTTOM FLAT

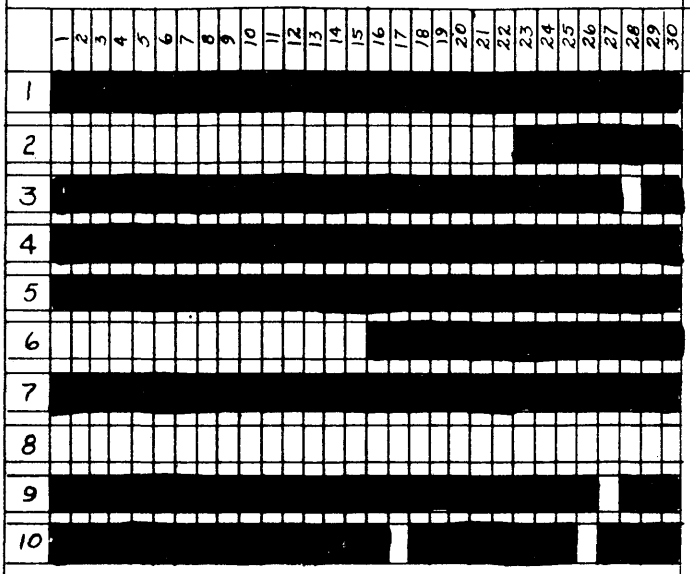


BOTTOM CURVED

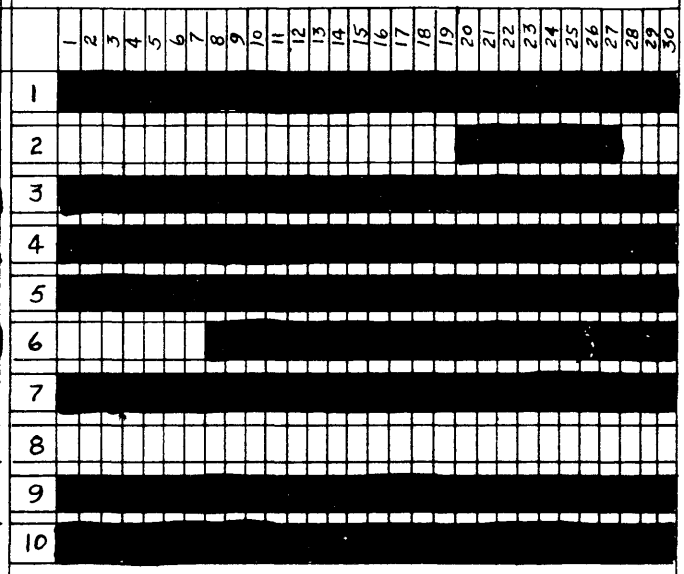


APPENDIX Z
CRADOCK VIEWING POINT NO. 10

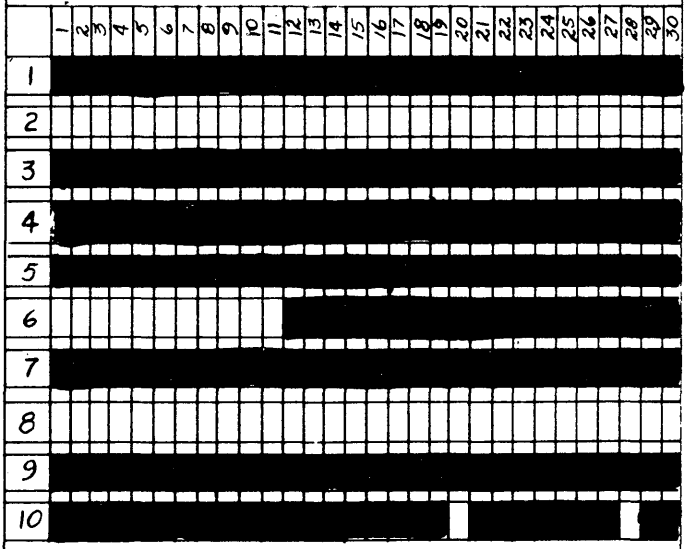
TOP FLAT



TOP CURVED



CENTER FLAT



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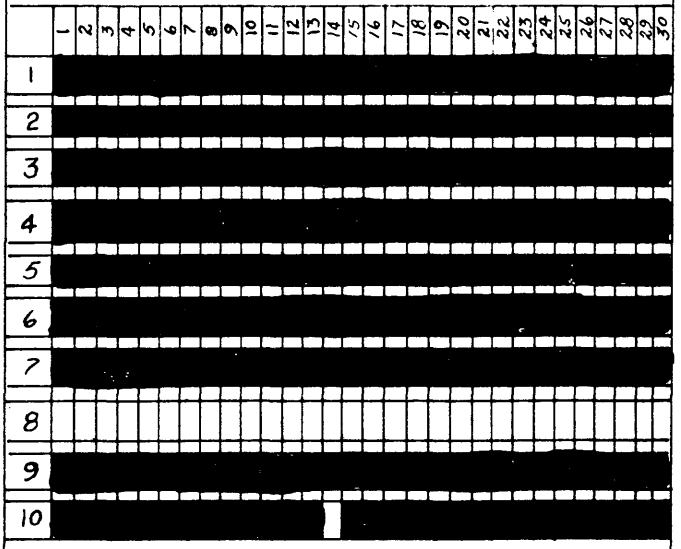
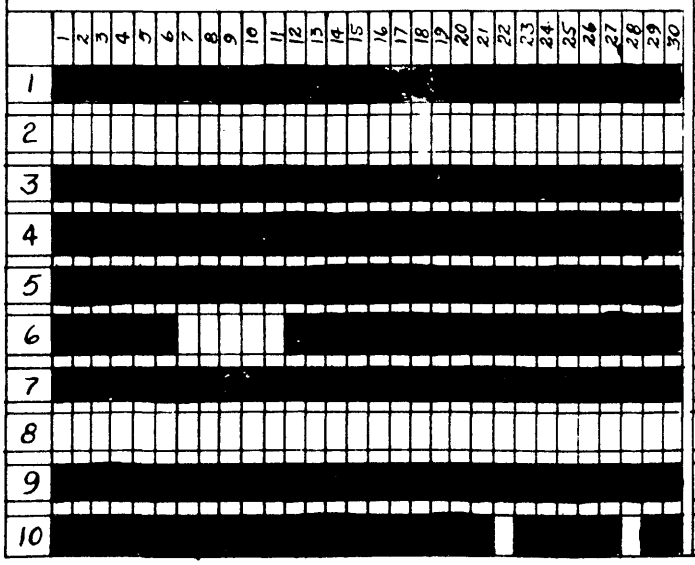
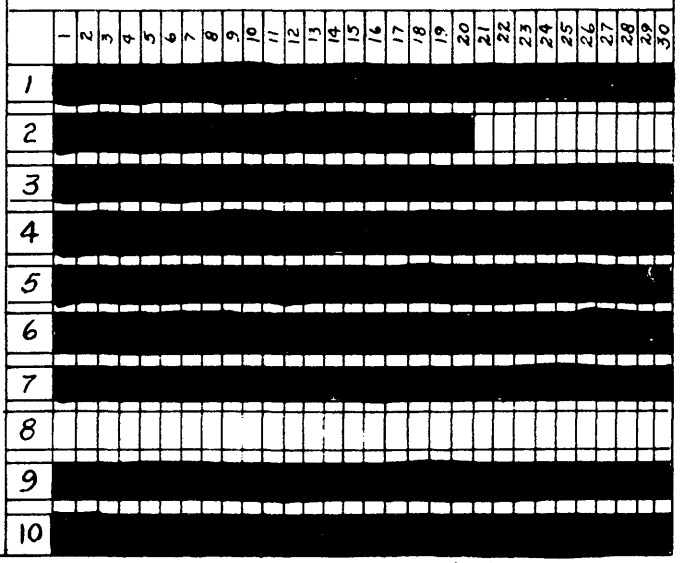


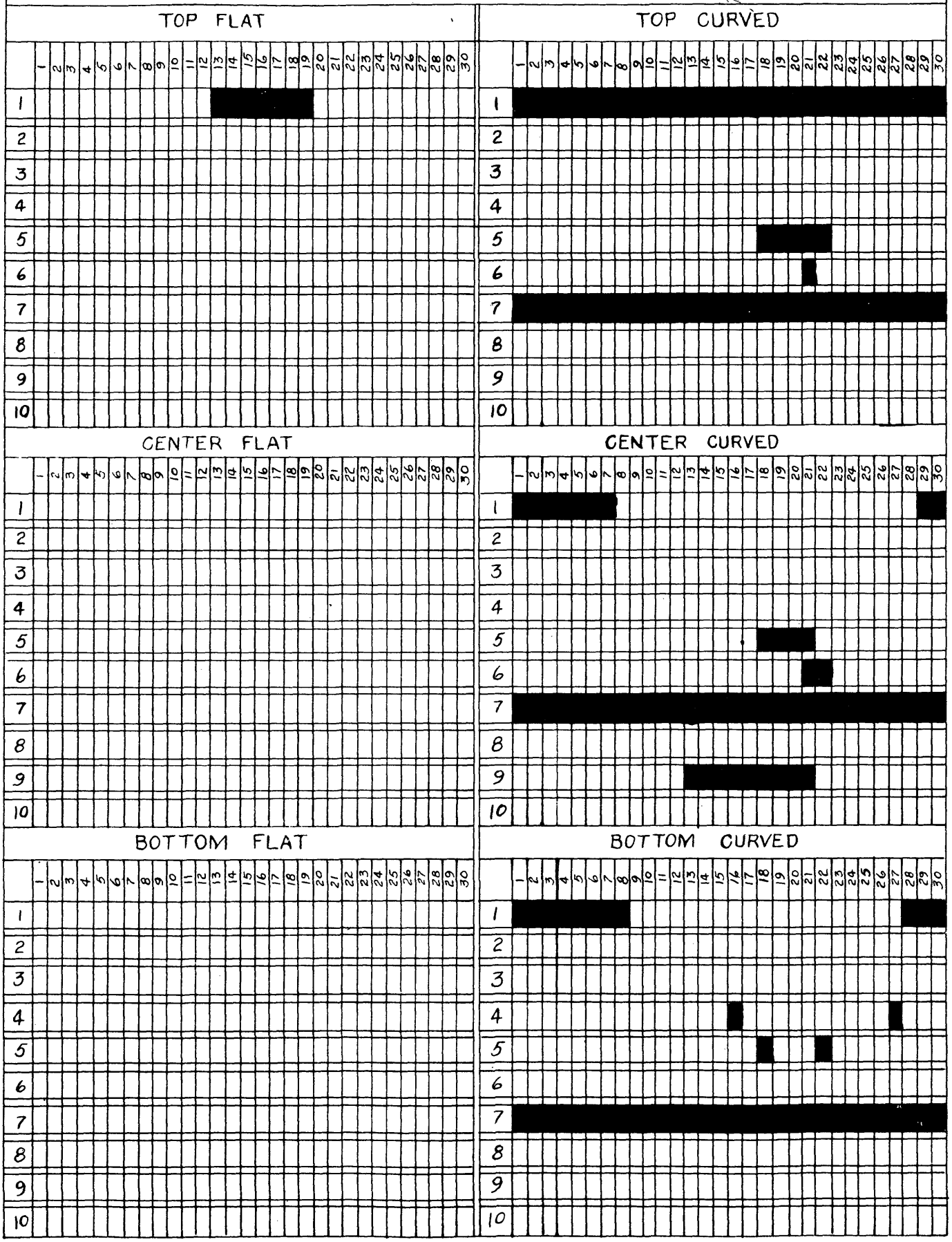
BOTTOM FLAT



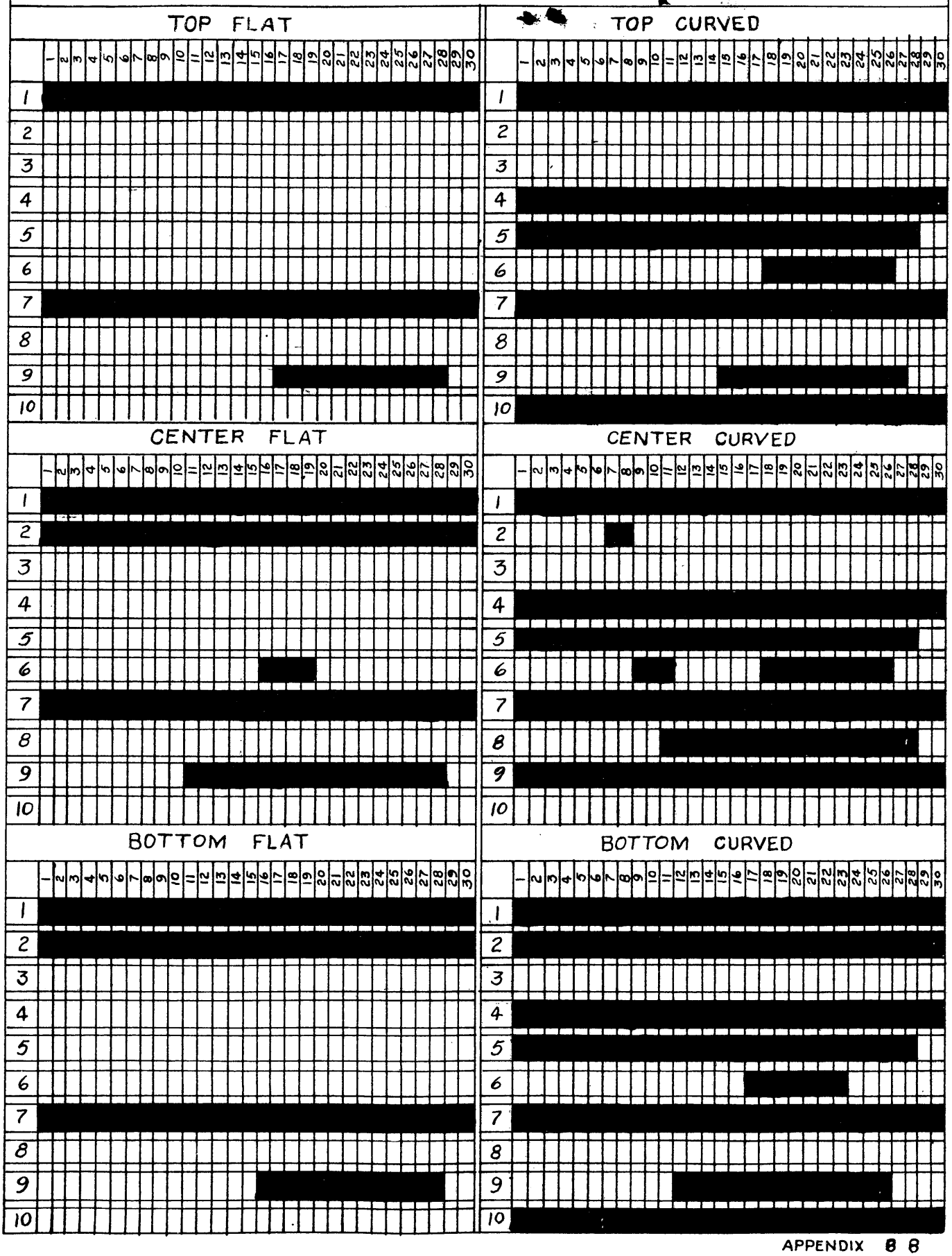
BOTTOM CURVED



APPENDIX AA
CRADOCK VIEWING POINT NO. 11



APPENDIX B B
CRADOCK VIEWING POINT NO. 12



FINAL COMMENTS OF CRADOCK SUBJECTS

TAPE RECORDED

Questions:

1. Your name, please?

2. You have now participated in this entire experiment--what are your over-all opinions of the curved board as opposed to the flat board?

3. Would you like to see this board used in classrooms?

4. Would it help you?

5. Do you have any comments about the test procedure itself?

Answers:

Q1.

Q2. It's definitely better.

Q3. Yes, sir.

Q4. Yes, sir.

Q5. No, I don't think so.

Q1. Carolyn Kennedy.

Q2. I like the curved board better. Because in most positions I could see more clearly the numbers and the lines.

Q3. Yes, sir.

Q4. Yes, sir.

Q5. No, sir.

Q1. Marjorie Melson.

Q2. It's much easier to read and I think it's easy on the eyes because it more or less follows the curve of the eyes. You don't have to turn your head--just more or less your eyes.

Q3. Yes, sir.

Q4. I think so, very much.

Q5. I think it was carried on very well and I think it's a good test.

Q1. Ronald Maxon.

Q2. Well, I believe that the curved board is best over a large area, because the plane board is all right if you are looking straight at it, but from an angle it has many difficulties and eye strains; and I believe over-all that the curved board is better.

Q3. I would.

Q4. I believe it would help me because it seems to take some of the train off of your eyes from an angle.

Q5. No, I thought that the test procedure was all right. It didn't tire us for looking at it. In the future the curved board will be the thing.

Q1. John Piner.

Q2. Well, the main thing I've seen, it seems to make it easier to see from more different angles.

Q3. Yes sir, I believe I would. It makes it easier to take notes from.

Q4. Yes sir, I believe so.

Q5. No, sir.

Q1. Sarah Little.

Q2. I like the curved board because I think you can see a whole lot more from the different positions. You can see much more from the curved board.

Q3. Yes.

Q4. I think it would.

Q5. No, except I think it's a very good idea and I have enjoyed doing this; I really would like to see the curved board used in classrooms.

Q1. Eugene Lopez.

Q2. Well, I think the curved board is much easier to read and count lines. It's better—much better.

Q3. I certainly would.

Q4. Yes, it would.

Q5. I think they were carried on right.

Q1. William Eckroade.

Q2. The figures are much plainer and easier to read.

Q3. Yes, I would. I see a great number of advantages to it.

Q4. Yes, I think so.

Q5. No, I think it was very interesting to participate in it and I think I gained a little knowledge from it.

Q1. Tommy Chilton.

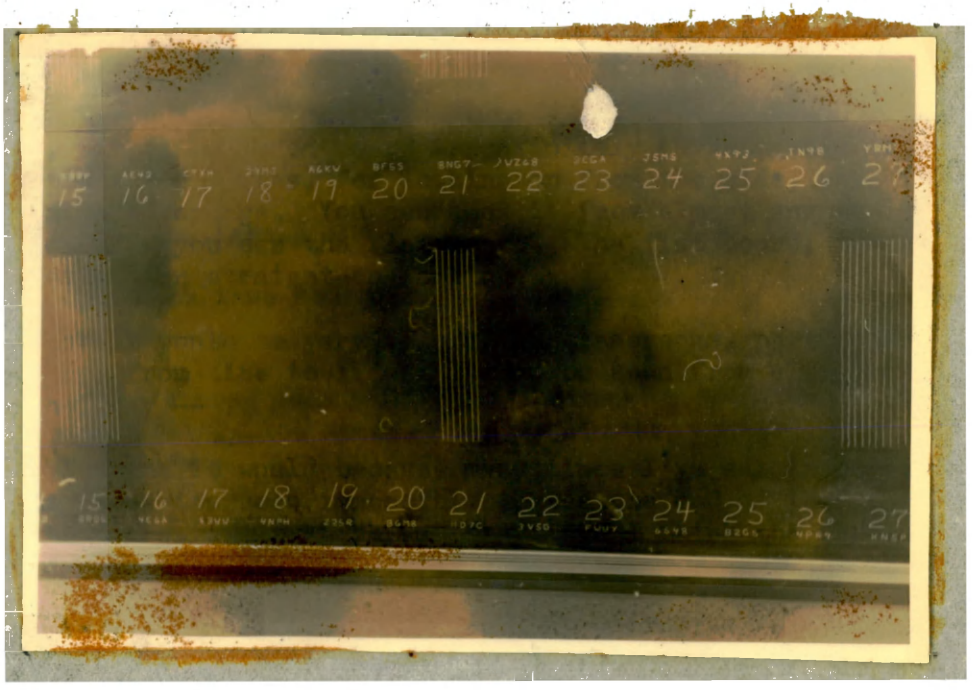
Q2. Well, sir, the curved board is definitely advantageous in certain positions for angles, for looking on from the side, why, it is a definite advantage. You can see it from almost any angle much better than you can the flat board. The flat board, though, I think is better for straight-on looking.

Q3. I think it would be very helpful in classrooms, particularly when looking from side to side. It can be seen from almost any angle. Which I say ---.

Q4. Yes, I think it would because many times I've sat in parts of the rooms where it's been impossible to see one end of the board because of the glare, etc., which was on it and I think the curved board would eliminate that.

Q5. Well, I think that it was a very well conducted test and I and from what I could see from it, it should be very conclusive; I believe that from the opinions gotten it will definitely show that the curved board has everything over the flat one.

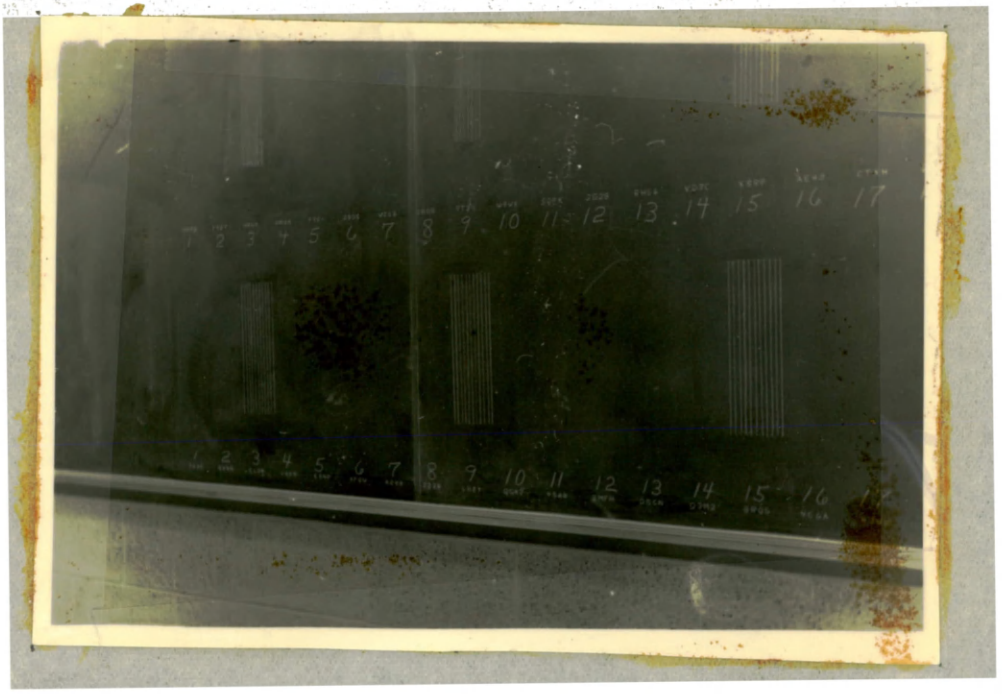
CURVED



FLAT

PHOTOGRAPHIC VIEWING POINT NO. 1; RIGHT SIDE OF BOARDS.

CURVED



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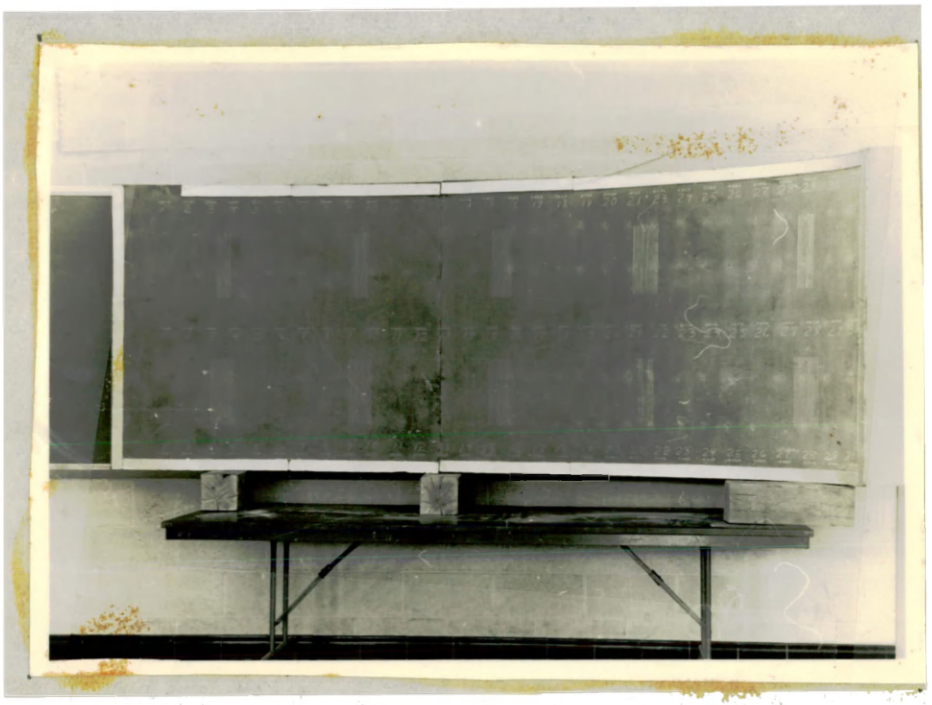

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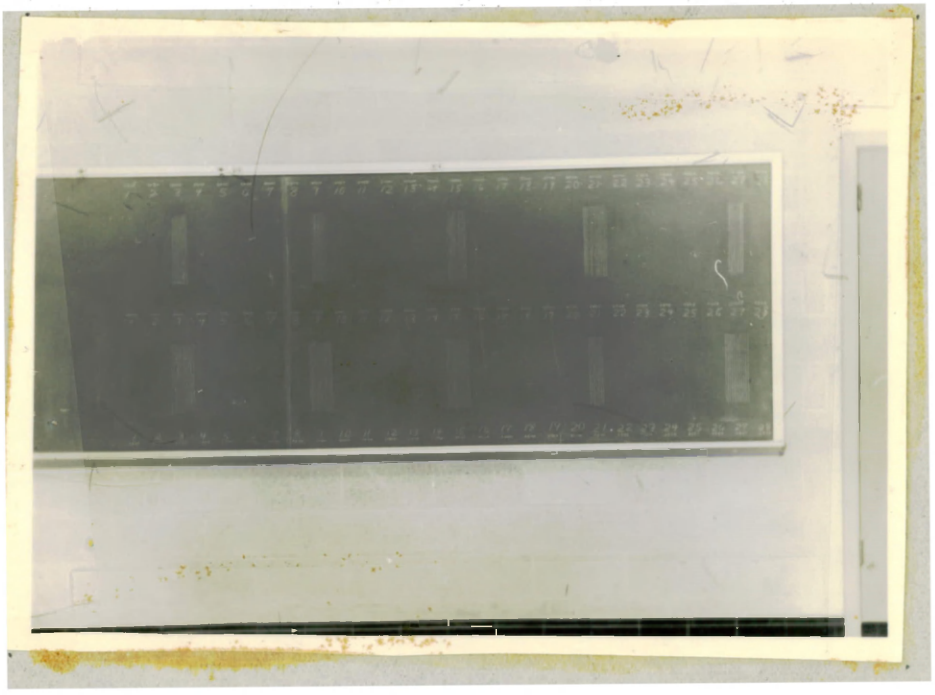

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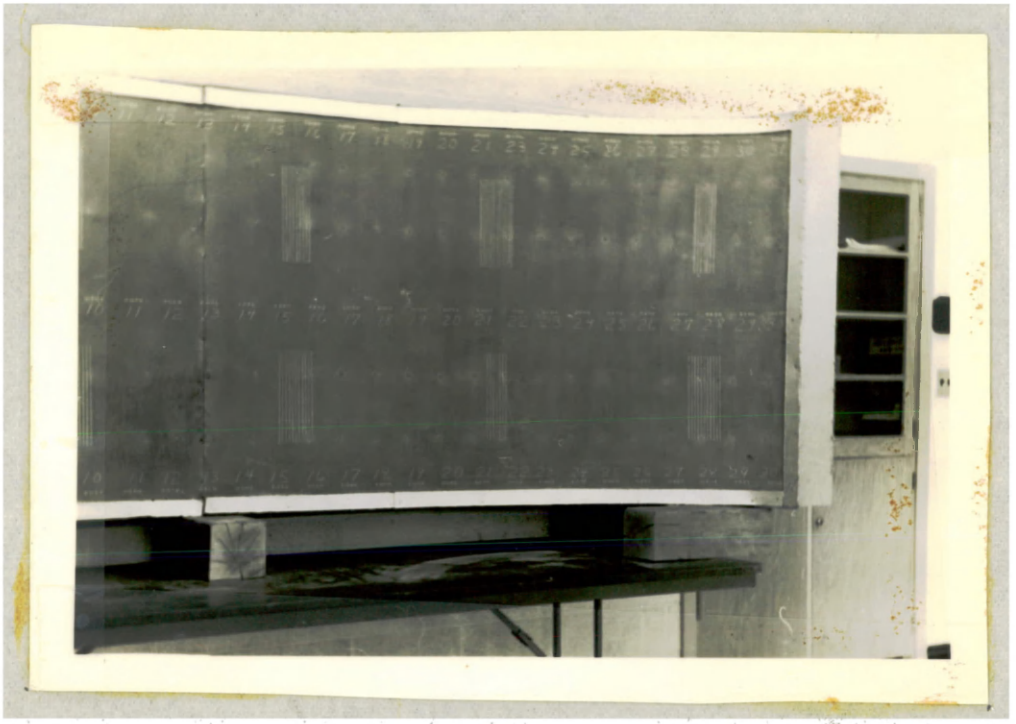

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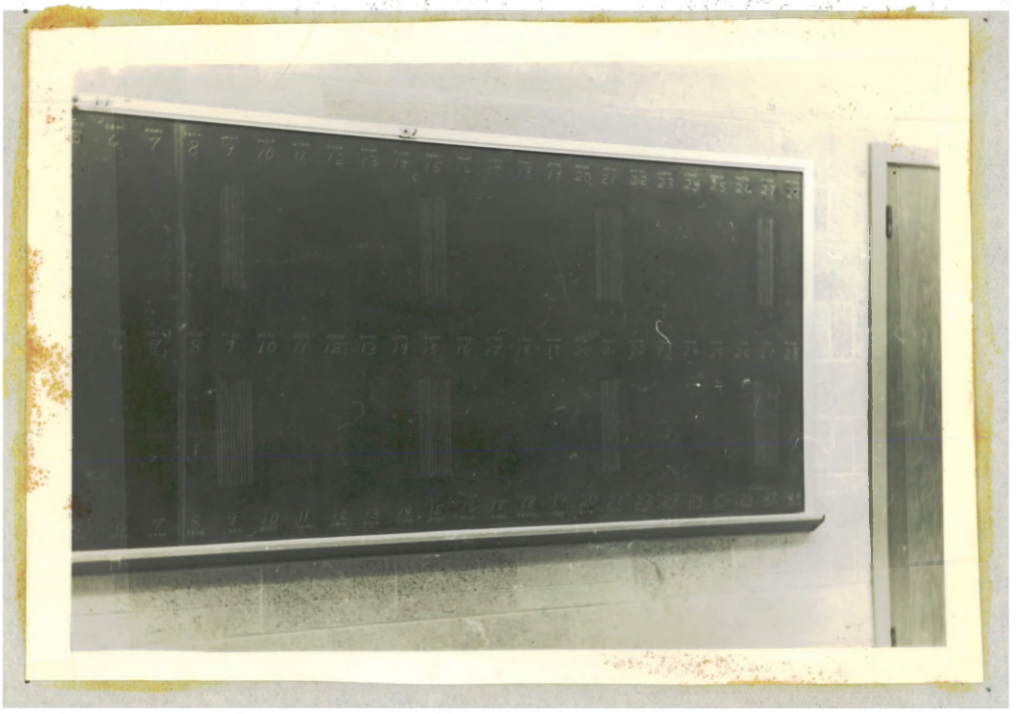

FLAT

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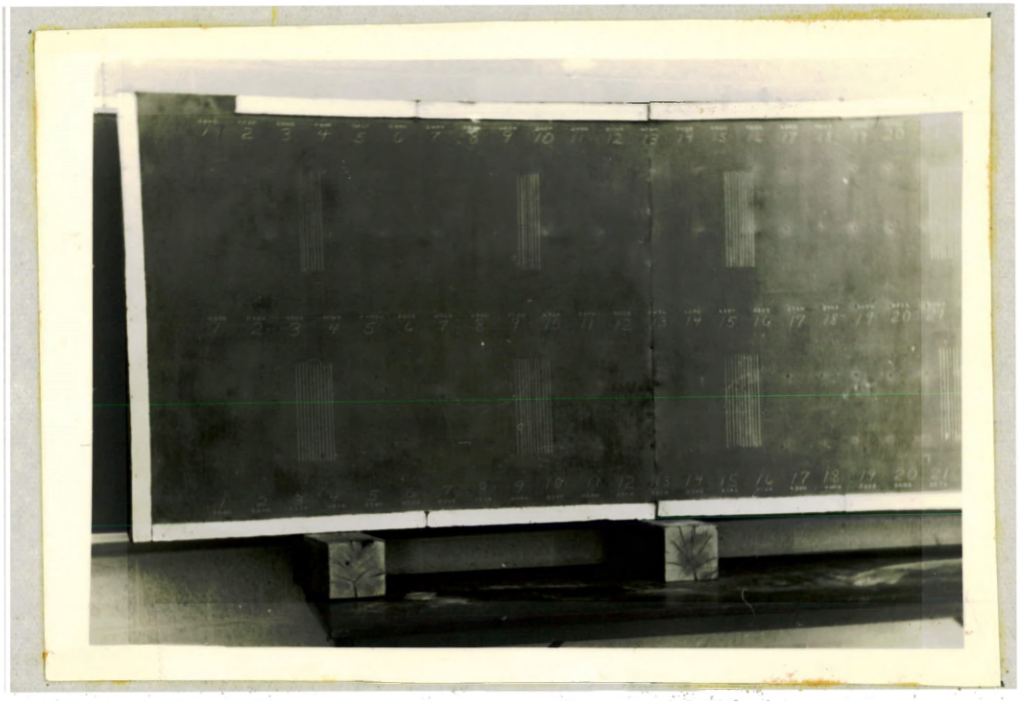

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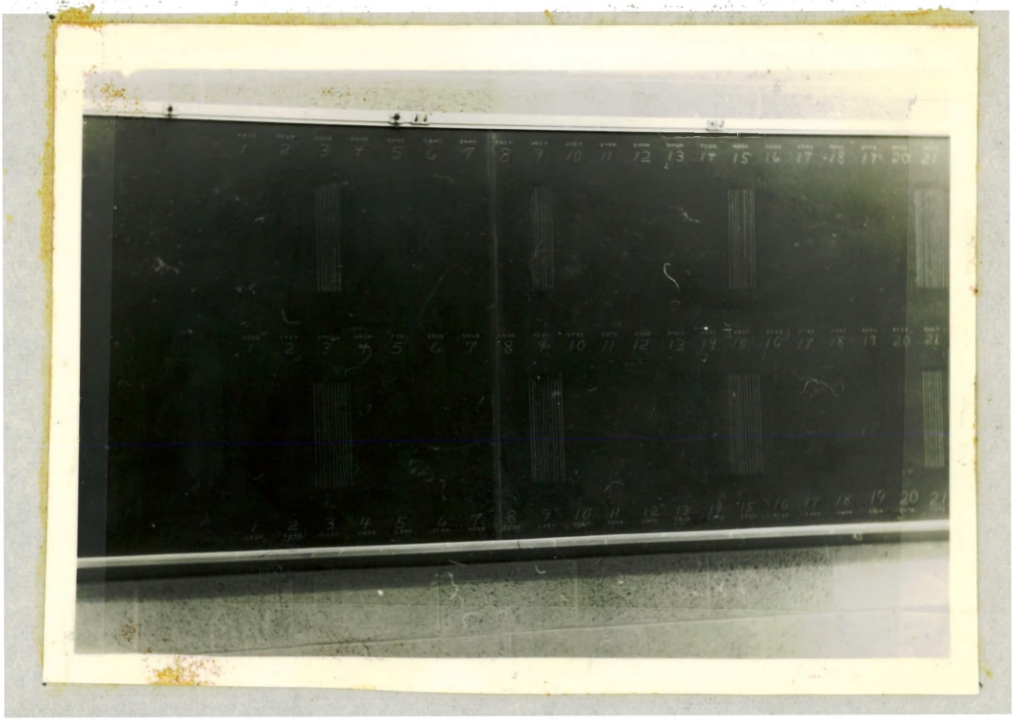

FLAT

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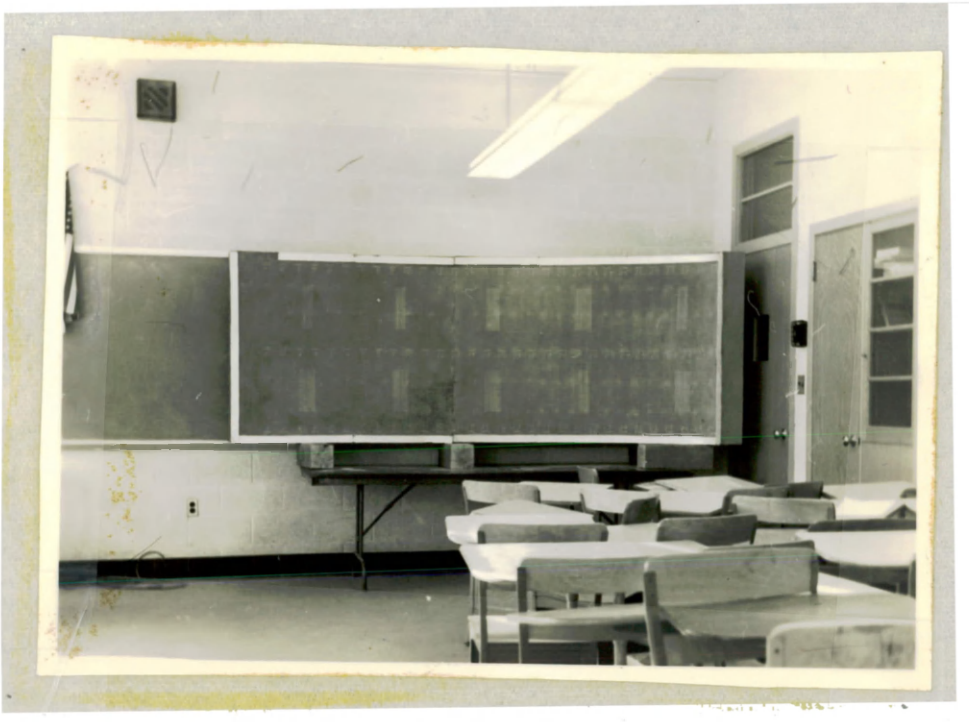

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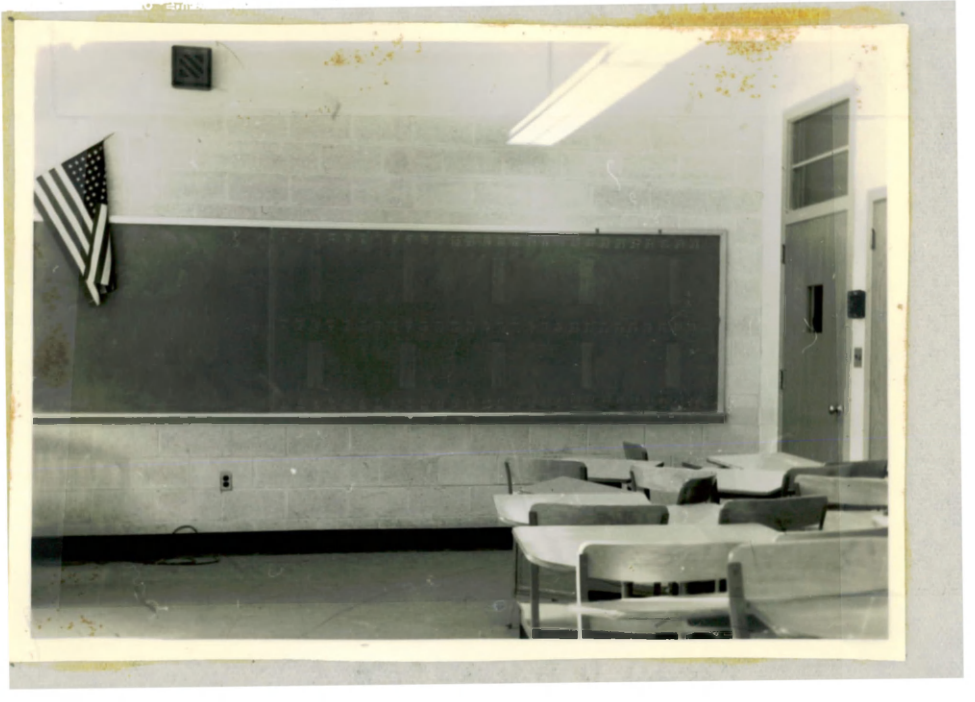

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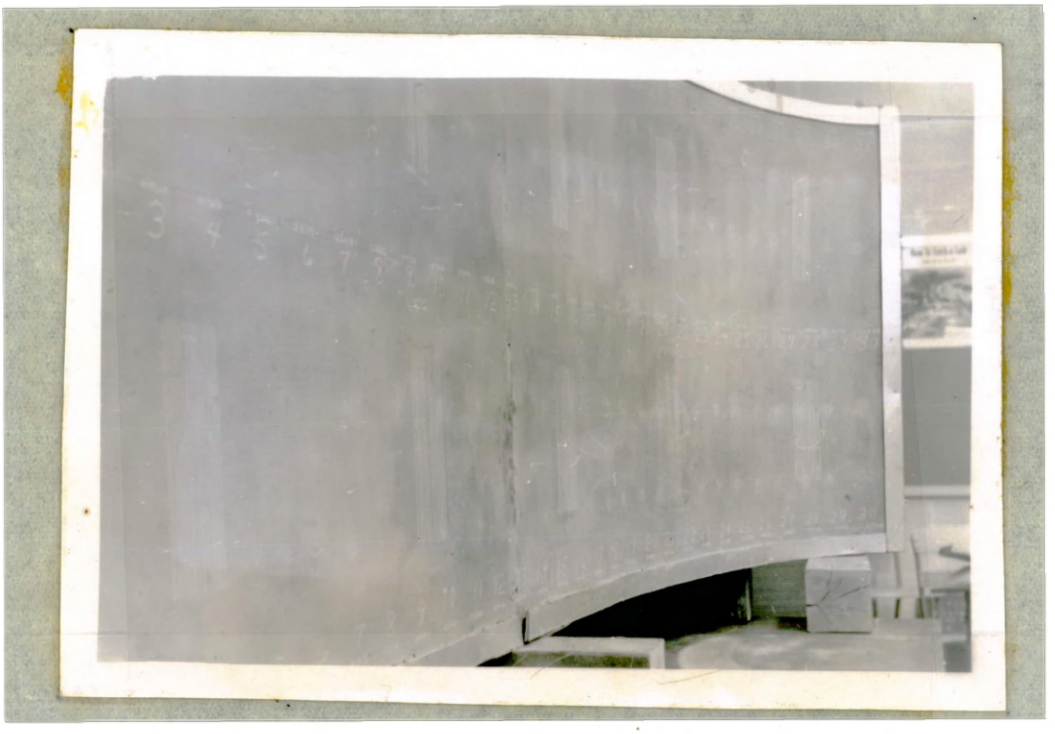

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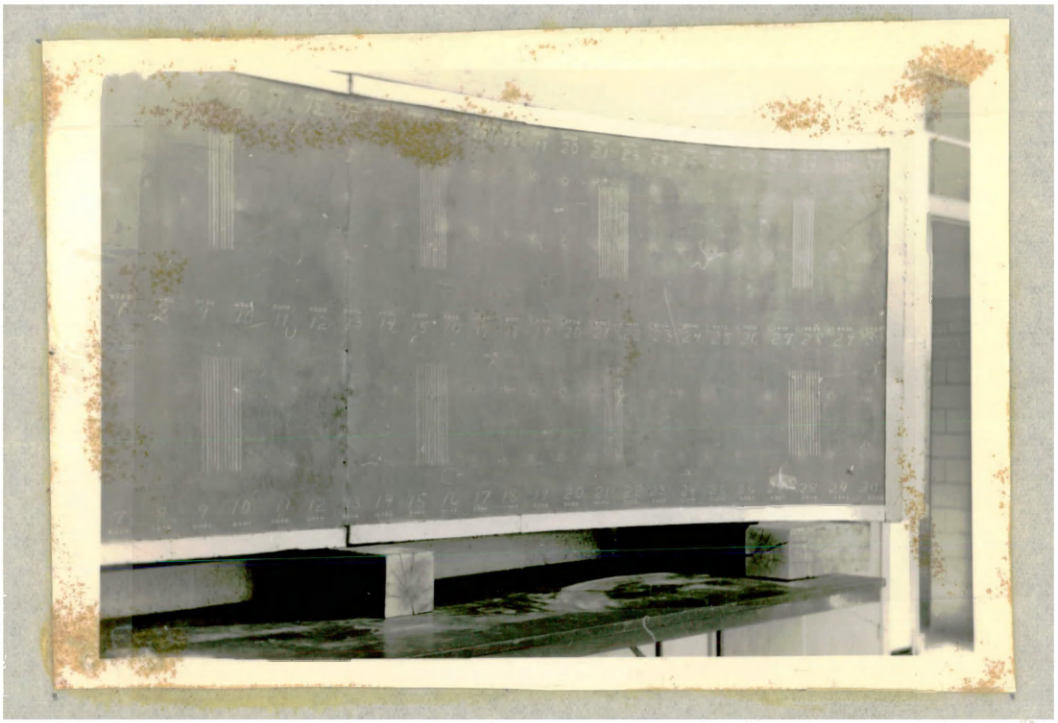

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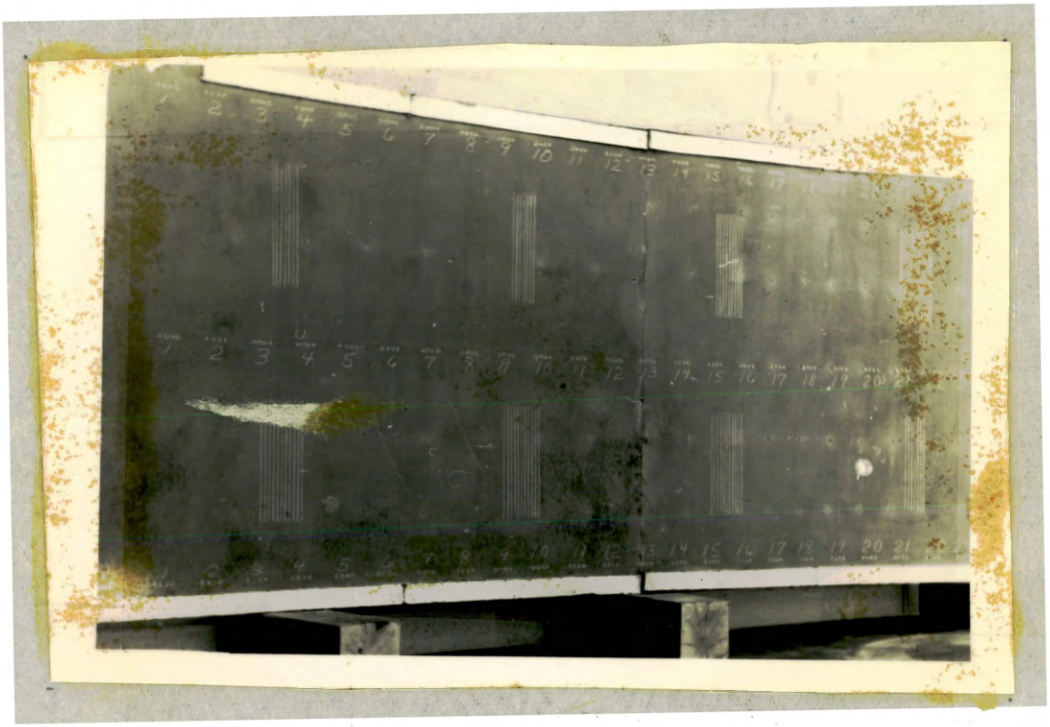

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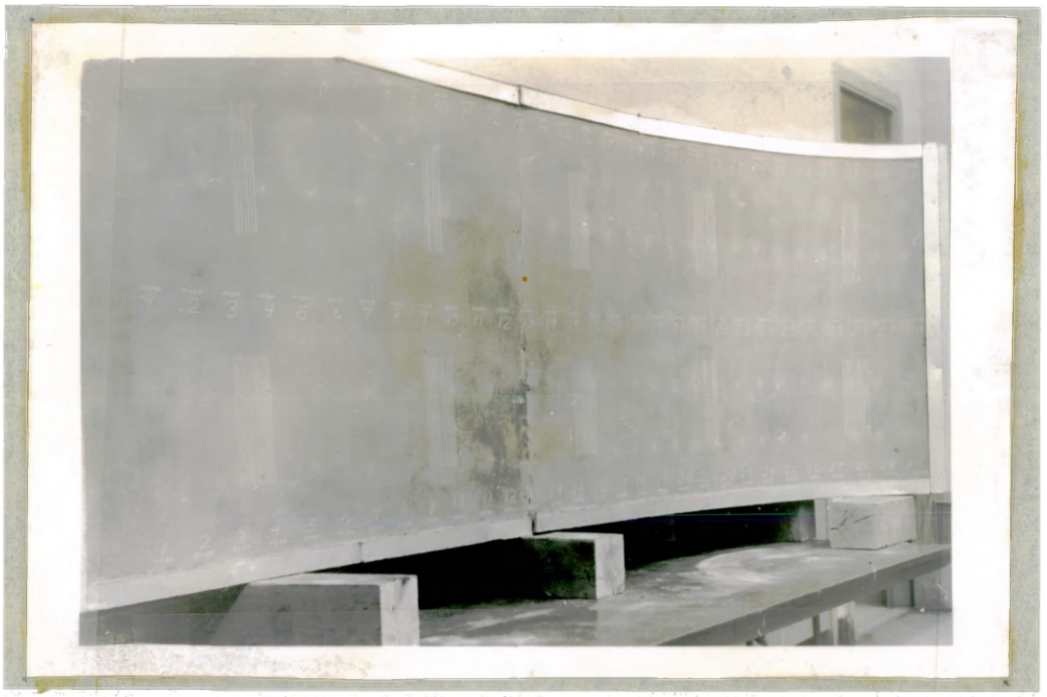

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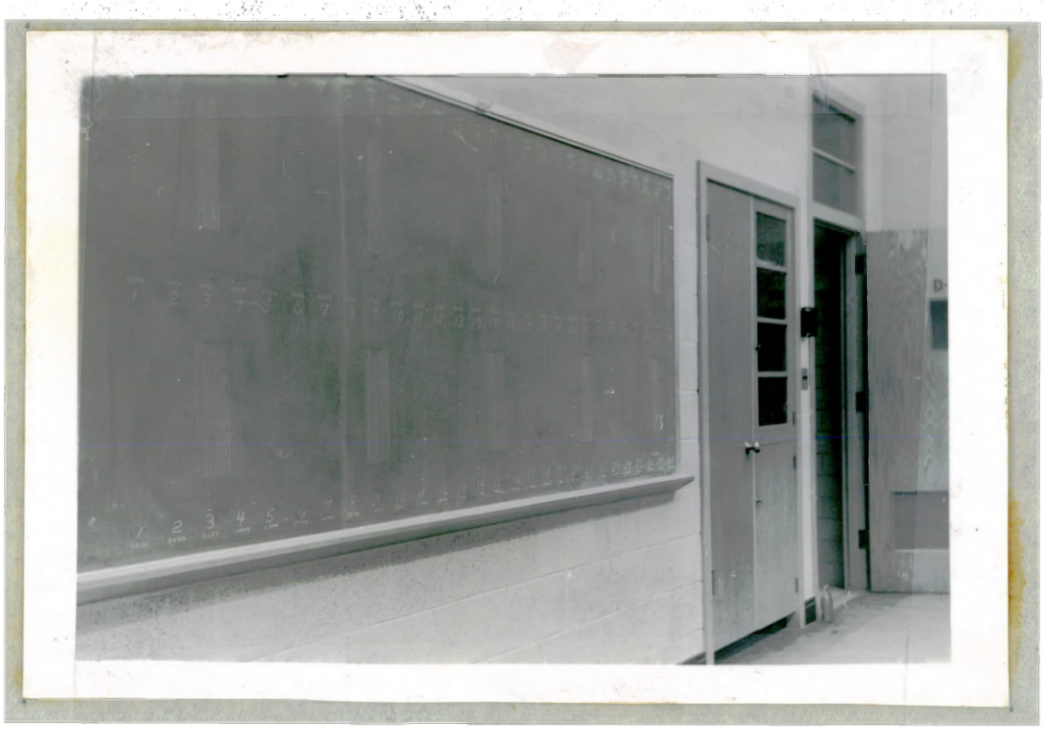

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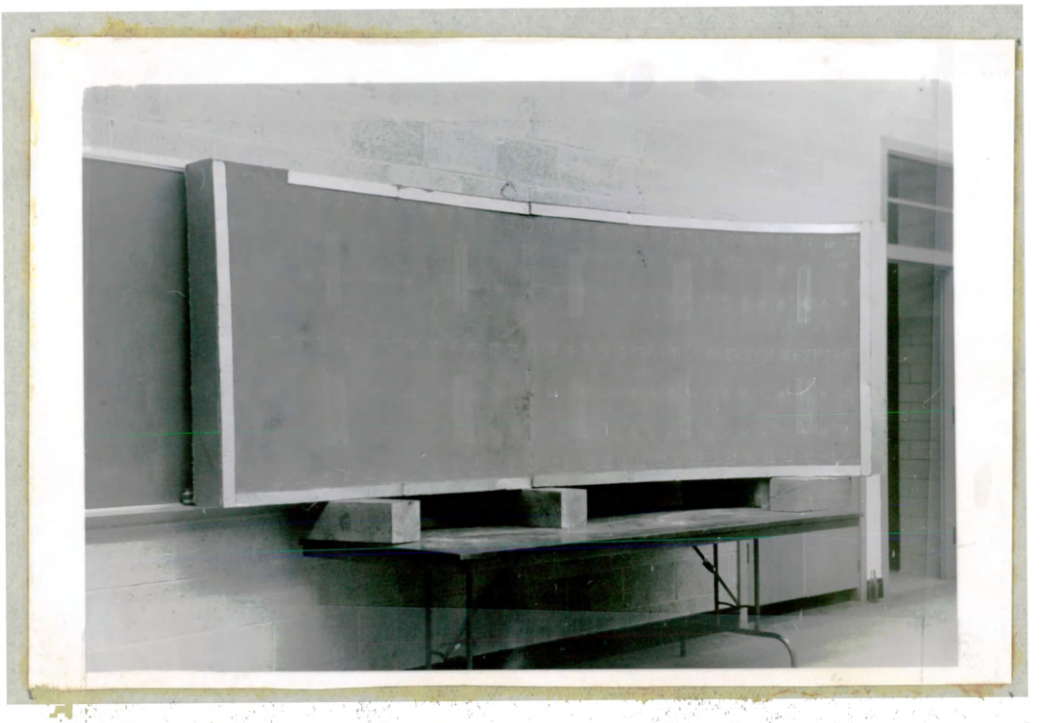

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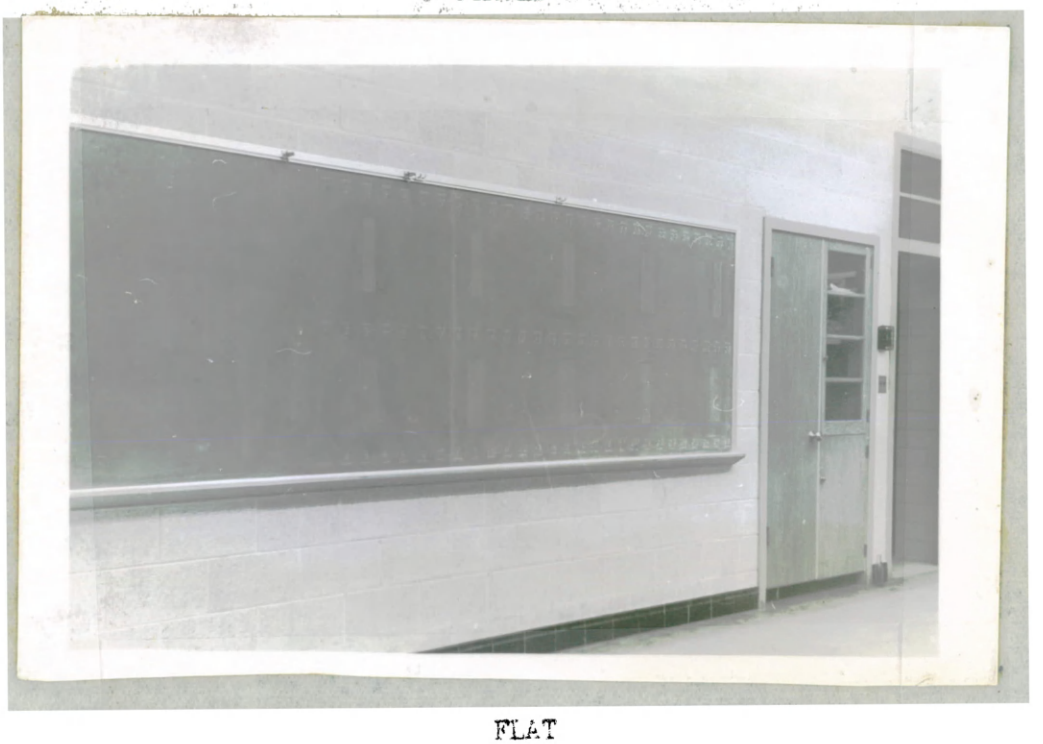

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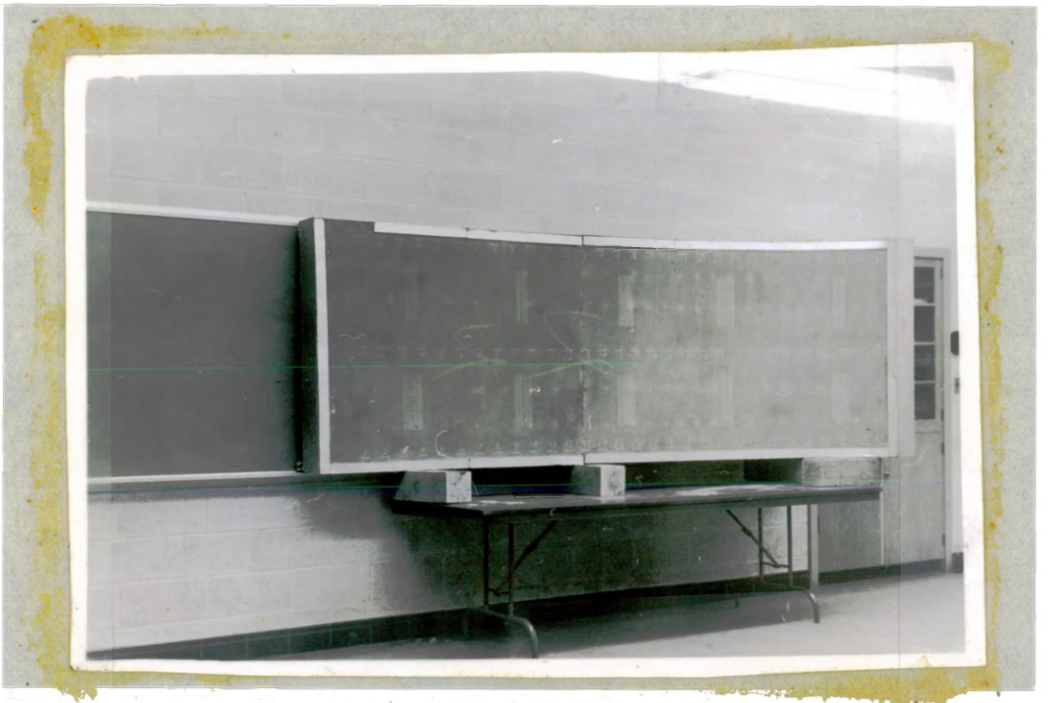

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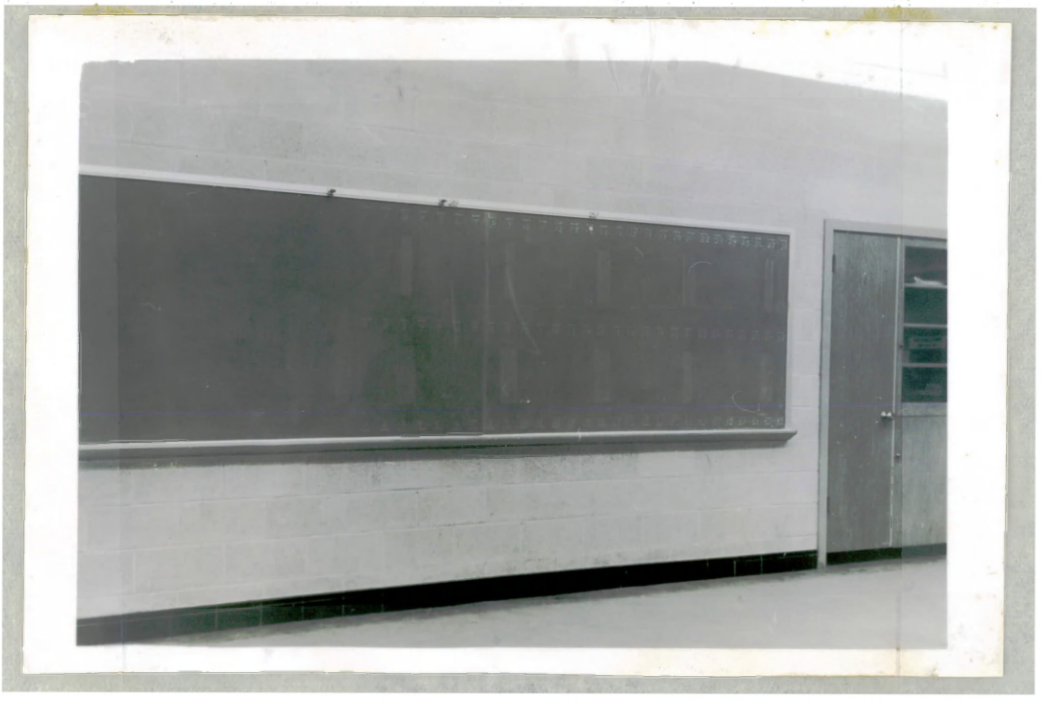

FLAT

PHOTOGRAPHIC VIEWING POINT NO. 31.

COLORED PHOTOGRAPHS OF TEST EQUIPMENT AND ITS ARRANGEMENT

BIOGRAPHICAL SKETCH

I was born and brought up in Greenfield, Massachusetts, and attended Deerfield Academy in Deerfield, Massachusetts. I was graduated magna cum laude from Bowdoin College in Brunswick, Maine, with an A. B. degree in mathematics. After attending Harvard Graduate School, I taught mathematics and coached athletics at Cradock High School in Portsmouth, Virginia. In 1954, I was called to active duty in the U. S. Army and was stationed at Fort Eustis, Virginia. Over the past two years I have completed the requirements for a Master's degree in education at the College of William and Mary. I intend to complete requirements for a Doctor's degree at the University of Virginia in order to further prepare for a career in education.