MECHANICAL AIDS TO ASSIST IN THE TEACHING OF DRAFTING

MECHANICAL AIDS TO ASSIST IN THE TEACHING OF DRAFTING

By

Rex A. Niles

Bachelor of Science in Education

Nebraska Wesleyan University

Lincoln, Nebraska

1932

Submitted to the School of

Industrial Arts Education and Engineering Shopwork

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

1949

APPROVED BY:

C. L. Hill

Thesis Adviser and Associate Professor
of Industrial Arts Education

DeWitt Hunt

Head, School of Industrial Arts
Education and Engineering Shopwork

Edward R. Stapley mez

Dean, Oklahoma Institute of Technology

H. C. McIntosh

Dean, Graduate School

ACKNOWLEDGMENT

The writer of this study wishes to express his appreciation to Mr. Cary L. Hill, for his valuable assistance in the planning and completion of this thesis; to Dr. DeWitt Hunt, Head of the School of Industrial Arts Education and Engineering Shopwork at Oklahoma Agricultural and Mechanical College, for his advice and suggestions; and to the librarians of Oklahoma Agricultural and Mechanical College who gave much of their time.

Gratitude is extended to my wife, Esther R. Niles; to my son, Douglas R. Niles; and to my daughter, Esther Louise Niles, for their inspiration, encouragement, and assistance throughout the preparation of this thesis.

Recognition is given to the manufacturing companies who so graciously furnished information and materials for this study.

Grateful acknowledgment is also made to my parents whose self-sacrifice made possible the education upon which this thesis is based, and whose memory is a constant source of inspiration.

R. A. N.

RESOURCEFULNESS

"No two situations are the same. There are times when tasks must be accomplished with limited working material. Resourcefulness must be developed that one may accomplish this purpose under adverse conditions and often under distinct handicaps."

Professor L. M. Roehl, Cornell University.

TABLE OF CONTENTS

CONTENT OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

Drafting in its essence is an analytic-synthetic procedure. The thought process must always follow a definite and sequential order. The very first step the student must take is to analyze the problem into its component parts; study each part carefully, closely observe each detail, collect all the facts bearing upon the problem in hand, and arrange them in their proper sequence. This step presupposes a comprehensive experience of factual knowledge, such as the principles of projection, as well as the meaning of every symbol, line, and figure. This analysis is obviously an intense mental process, and must take place before a line is made on paper. The second step is the formulation of specific conclusions from the facts, as the correct method or procedure in the solution of the problem. In this step, the thought is completed, and the student is ready to apply the knowledge gained in the first two steps. The actual drawing or application is the third and final step of this process. The student in drafting must invariably follow these three steps, observation, reflection, and application or execution.

The hand cannot be trained before definite and clear concepts have been formed. Muscular activity begins only after the mental processes have been completed. Thus, a complete co-ordination between the mind, the eye, and the hand can be established and maintained. It is folly to talk of the training of the hand without taking into consideration the role the mind plays in this training process. It is what takes place in the brain that gives drafting its greatest value.

It is obvious that drafting, when properly taught and motivated, develops clear and definite concepts, stimulates exact thinking, and forcefully demonstrates to the student the need for systematic methods of procedure in the solution of a problem.

The Problem Stated: The title: "Mechanical Aids to Assist in the Teaching of Drafting." This study is made to obtain definite and firsthand knowledge of the value of mechanical aids and to determine whether or not they may be of value in the industrial arts drafting curriculum.

To justify continued place in the curriculum of the public school, a subject must be one with content accepted as valuable for the students who pursue it, and one of method so effective as to insure reasonable mastery of the content. Drafting is one of the industrial subjects, introduced early in the movement for "practical" offerings and is today universally taught where industrial arts or trade training is recognized in the schools. Because it is so widely offered, it is quite logical and necessary that attention be given to basic studies of mechanical aids in this field. Drafting instructors need factual evidence in order to better recommend improvements in its materials and methods.

As the industrial arts instructor extends his knowledge of what and how to teach, he is forced to the conclusion that past and present practices are as varied as the number of teachers. The field of drafting is not unique in this respect. Very few attempts have been made to establish the superiority of any given method or procedure. Since drafting instructors are attempting to prepare students to take their places and to function adequately in society, it is their duty to investigate all possible questions relating to worth-while pedagogy and presentation of subject matter. It is in keeping with this belief that the material presented, here in, was undertaken.

<u>Purpose of the Study</u>: This study of mechanical aids is being made for the purpose of planning the procedures that might be used by an instructor who is introducing the subject of drafting into the industrial arts curriculum for the first time. All the equipment introduced is practical and common enough to justify its use in such a course. There is a great need for well planned drafting rooms, class room teaching aids, and the more useful methods of duplication that will help the instructor eliminate many of the common mistakes, made in the establishing of a drafting department.

Specifically the purposes of the study are:

1. To classify the types of duplication, that could successfully be used in a drafting department.
2. To promote a clear understanding of the simplicity of the more common useful types of duplication, and their application to the teaching of drafting.
3. To arrive at the most satisfactory procedure of planning a drafting room.
4. To facilitate the mechanics of organizing a drafting class, for permanency of data, economy of space, accessibility of floor space, and storage of supplies.

<u>Limitations of the Study</u>: Perhaps the most important limiting factor of this study is time. A survey of manufacturing concerns, in which drafting plays a vital part, would be interesting and beneficial.

Statements of leading educators, concerning the value they place on mechanical aids to assist in the teaching of drafting, would greatly add to the study if time permitted.

It would be a presumptive thesis indeed, that would pretend to explain accurately down to the last detail, the workings of the vast amount of mechanical aids in the teaching of drafting. The reading of volumes of material are no parallel for practical experience. This may contribute a background for better understanding, but provides no substitute for firsthand information gained by actually seeing the various aids in operation.

This thesis is no encyclopedia. It contains no mathematical problems, or detailed discussion of intricate construction, complicated processes, maintenance methods, or visual aids. The author is not an engineer but an instructor, starting from the beginning in this matter of mechanical teaching aids. With this aim, the discovery of the answer to general questions from the instructor's point of view will be accomplished. Wherever possible, the technicalities have been taken out of what threatens to be a highly technical subject. The writer wishes to succeed, in even a small way, the development of what is certainly an important subject by making it more comprehensible. If this is accomplished, then this writing is worth its while.

Research Technique: In the writing of this thesis the library technique was applied, for all available material, in seeking the facts necessary to presenting this study of mechanical teaching aids. The history of duplication was reviewed with an attempt to obtain the earliest possible origin of the process. Books and articles written by recognized authorities were used as references in discussing the methods of duplication. In regard to the mechanical aids listed, the writer has supplemented the research with the experiences of instructors in the field of drafting, and the personal experience of the writer.

Definition of Terms: In order to clarify the concepts represented by special terms used frequently in this study, the following definitions are offered. The definitions found in existing literature are given proper references, otherwise the definitions are proposed by the writer.

Drafting. The art of drawing. (8, page 124)

Mechanical Drawing. Drawing accomplished with the use of instruments. Technically, the term includes orthographic projection, architectural and engineering drawing, various kinds of perspectives, and projections. (8, page 248)

Industrial Drawing. This includes mechanical drawing, machine drawing, patent-office drawing, pipe drawing, charts, diagrams, graphs, maps, tables, electrical drawing, furniture drawing and design, sheetmetal drawing, structural drawing, and any drawing used in industrial pursuit. (29, page 3)

Sketch. The outline of chief features of an object, usually drawn freehand, and serves mainly as a rough draft. It should give complete information regarding size. It is usually made as a preliminary step to a finished drawing. (29, page 3)

Hectograph. A gelatin pad for making multiple copies of drawing or writing. (16, page 193)

Duplication. Process of reproducing a number of printed, drawn, typewritten, or handwritten copies of material needed for some specific purpose.

Stencil. A piece of thin sheet metal, parchment, paper, or the like, so perforated that when it is laid on a surface and color or ink is applied, a desired figure is produced. (42, page 975)

Mimeograph. An apparatus in which a thin paper, coated with paraffin, is used as a stencil to reproduce copies of writing or typewriting. (8, page 252)

Photochemical. The using of reflected or transmitted radiant energy, in the form of light, to cause chemical changes to take place on sensitized paper, cloth or film.

Blueprint. Drawing which has been transferred to chemically treated paper by exposure to electric light or sunlight, and then processed. Process known as "blueprinting." (28, page 533)

Ozalid. The name applied to a German process, whereby paper sensitized with diazo compounds and exposed to ammonia vapor, will yield a positive image. (36, page 41)

Equipment. Any tool, either major or minor, that makes it possible for a person or persons to express themselves to advantage through the materials of their choice.

Industrial Teacher. A progressive industrial teacher is one who is "going places." He is one who is not satisfied with present achievements; he is striving toward goals not yet realized. The progressive teacher thinks in terms of what lies before him. (41, page 4)

Laboratory. The term "laboratory" is gradually replacing the term "shop" in many progressive schools. The term "laboratory" infers a type of industrial arts instruction based on student development in which there is freedom for creative and investigative work as well as the making of projects. (22, page 133)

Creative Teaching. Creative teaching uses the tried ideas of yesterday, but more extensively the mature judgment of today and the evolving ideas of tomorrow. (41, page 569)

Need for this Study: Drawing is the universal graphic language of the world. Proficiency in the expression of this language cannot be acquired by one who has not first mastered the technique in the handling of mechanical devices, with which this language is expressed. With correct mechanical devices and proper guidance, there is little to prevent a student acquiring the manual dexterity which he needs to produce the best work in the least time. Instill in the student the idea that the measure of one's ability is power or rate of doing work and not just work without the time element.

If all implications are carefully weighed, it may be rightfully assumed that drawing should be offered to all students as a general subject in the junior high school. It should no longer be considered simply as shop adjunct, but a language subject useful to all. Since it is useful to many individuals in different walks of life, course offerings should be patterned more closely to the life situations of the ordinary individual.

The means of interesting the student in general drafting is to teach the student by a series of easy, carefully graded instruction sheets. Through these, he acquires the essential techniques of the art of drafting. In this manner, the student will acquire dexterity in the use of the mechanical devices placed at his disposal and acquire a working knowledge of the essential phases of drafting.

Instructors will find that students are encouraged to put more effort into their work, if a specific system of grading is used. The point system is easily explained and may be used with a great deal of satisfaction. More consideration of the quality of the drafting, rather than in the quanity, gives the student a clearer understanding.

The instructor should develop the facility of ease in making teaching aids, the prime function of a drafting course. The student will not acquire the ability of visualization, neatness, accuracy, or speed without the ability to manipulate with dexterity, the mechanical devices placed at his disposal by the instructor.

CHAPTER II

REPRODUCTION AND DUPLICATION

Duplication is the process of reproducing a number of printed, typewritten, drawn, or handwritten copies of material needed for some specific purpose. The actual work involved in duplication is often one of the service functions performed by the drafting instructor. Bulletins, reports, charts, graphs, maps, instructional material, many types of industrial arts forms, drawings of many types, and tests can be reproduced profitably on appropriate devices.

Although duplication processes and machines are adapted to many needs, some are intended for certain kinds of work. In selecting the proper process or machine, the drafting instructor should consider its application to the work, together with the speed, ease of operation, durability, and cost factors.

Various Processes: The various processes may be grouped in accordance with the general similarity in methods. The mechanical processes, Part A which follows, form a group which includes carbon copying, hectographing, and mimeographing. The photochemical processes, using reflected light, include photography and photocopying. The photochemical processes, requiring transmitted light, Part B, include Blueprinting, Ozalid Printing, BW Process, and Van Dyke. (28, page 533)

There are many types of reproductions and many methods for making them. This thesis deals only with the most important methods, and will describe the types of reproductions and the various methods used to produce them. It is not intended to give a complete and detailed description of every operation necessary to procure copies of a needed material. But rather to convey a general idea of the different processes used.

Part A

CARBON COPY

The carbon copy method of duplication is one of the simplest and least expensive methods, if only a few copies are required. With the firm striking of the keys of a typewriter, it is possible to produce as many as 10 copies on thin tissue paper at one writing.

DUPLICATING BY HECTOGRAPH

In the up-to-date office, or school, modern duplicating equipment has largely supplanted the hectograph. This simple device, however, continues to be sold, and used, in large numbers indicating that it must have some advantages over the modern methods.

"Hectograph" comes from the two Greek words "heoo" meaning hundred and "graphein" meaning to write. This descriptive name is suitable, for under ideal conditions the hectograph will produce about one hundred legible copies. Webster's dictionary describes it as a "contrivance for manifolding a writing by transferring it to a slab of gelatin treated with glycerin, and then taking transcripts from the gelatin."

There are several types of duplicators which fit the dictionary description. Many of these, however, are better known by trade names. In general, the term "hectograph" has come to refer to the most simple style of gelatin duplicator, the pan style. The writer will use this term in the writing of this thesis. (33, pages 299-300)

Famous Inventor: It was in 1780 that the versatile inventive mind of James Watt of steam engine fame developed the first method of office copying. By writing his original with a flutinous ink, he was able to produce a few identical copies by pressing moistened sheets of very thin paper against the original. These copies, then have to be read through the paper since the transferred image was a negative. This, obviously, necessitated extremely thin, transparent paper.

Strangely enough, the English business men objected strenuously to Watt's invention because they feared that it would lead to forgery. This prejudice undoubtedly was one of the main reasons for the negligible success of Watt's invention. It was not until the advent of the gelatin process a century later that this type of office printing came into favor. (31, page 67)

German Discovery: Alexander Shapiro originated the hectograph or gelatin process in Germany in 1880. His discovery was not put into widespread practical usage, however, until 1900. At this later date and shortly thereafter, several gelatin duplicator companies were organized, and this method of reproducing ten or fifteen economical copies began to come into its own. (6, page 46)

Container: The hectograph consists of a flat container filled with a gelatin compound and a cover to keep the surface clean and to prevent drying out. Sometimes simple metal pans with separate lids are used as containers. Others are made from wood. These are often "double" or "book style." That is, when opened the box reveals a gelatin surface on each side, the two sides being hinged together.

The containers vary in size, but should be somewhat larger than the copy paper so that the copies may be easily lifted from the gelatin.

Gelatin Compound: The gelatin compound must be replaced if the hectograph receives extensive use. With care the original compound will do 75 to 100 printing jobs. It finally becomes so ink-filled that good results are unobtainable. The gelatin compound may be purchased in one pound and two and one-half pound cans. The can is placed in a pan of hot water until the compound is melted. The compound then may be poured into the pan from which all of the old compound has been scraped. The pan is then allowed to cool, on a level surface, while the compound is hardening. A pitted or damaged surface may be renewed by remelting the compound and pouring it back into the pan. After the compound has been poured, bubbles appearing on the surface should be drawn off with the edge of a paper card. If this isn't done, a pit will appear at the site of each bubble after the hectograph is used. (16, page 193)

Master Copies: Master copies and impression copies should be made on a hard surface paper. Soft papers absorb too much of the ink and make a fewer number of legible copies. Master copies may be made in a number of ways. Hectograph ink may be purchased in several colors. The old stand-by is purple. It seems to hold up better, for more copies, than some of the other colors. Red, however, gives very satisfactory results. Other colors of ink available are blue, black, and green. Black appears more like blue on the copies. Ink bottles must be kept tightly corked or covered as the ink thickness rather rapidly. It is well to examine hectograph ink before purchasing it.

Quite often the ink thickens on the dealer's shelf due to improper corking. The pen should be cleaned immediately after finishing the inking. Often it is necessary to wash and dry the pen during the inking process as an accumulation of dried ink on the pen tends to widen the lines and make a blur. Hectograph pencils are available in violet and other colors, although pencils produce fewer copies than inks or carbons.

Hectograph Ribbons and Carbon Paper: Hectograph ribbons for the typewriter are convenient to use. These come in purple and red. Hectograph carbon comes in various colors. Here again, the purple seems to give the best results. Unit master carbons may be purchased. These are designed for the type of duplicator which takes a reverse copy. However, they may be used on the pan style duplicator by reversing the unit and typing on the back of the carbon sheet.

Transfer Principle: The hectograph operates on a transfer principle. The message is drawn, typed, or written on the master sheet. The surface of the gelatin is washed with a sponge or lintless cloth and warm water. Excess water is sponged away. A little practice will show the user how damp the surface should be. The master copy is laid face down on the gelatin and smoothed well to insure complete contact. After a minute or two, the master copy is on the gelatin surface. As soon as the master copy is removed, one may begin making copies by smoothing pieces of copy paper over the inked surface one by one and removing them immediately. As each copy is removed, it takes with it a very thin coat of the gelatin and an impression of the printed, written or drawn message on the master copy.

When the desired number of copies have been made, the surface of the gelatin should be washed off with warm water and the excess water sponged away. The amount of time which elapses before the surface can be used again varies. If the previous inking was light and the surface thoroughly scrubbed with hot water, the surface may be used immediately. However, the hot water and scrubbing dissolves a considerable amount of the compound and tends to make the surface of the gelatin uneven. It is better to wash the surface with moderately warm water and allow it to stand a day or two or longer, before attempting to use it again. Special soaps may be purchased for easy removal of stains left on the hands when handling the inks and carbons. (31, pages 68-70)

Advantages: The advantages of the hectograph are; (1) it is economical, (2) it is available, (3) it requires a small amount of storage space, (4) it is relatively light in weight and portable, (5) multiple coloring may be used in the drawing, and (6) reverse master copies are not required.

Disadvantages: Some of the disadvantages of the use of the hectograph instead of other duplicators are; (1) it is a slower method, (2) fewer copies may be made, and (3) black printing is not possible.

It may be concluded that industrial arts duplicating definitely needs a quick, economical method of reproducing a small number of copies of instruction sheets, drawings, shop forms, etc. The gelatin or hectograph process is the practical answer to that need. It is not intended for long runs, or for making permanent records, or for duplicating that requires sharp, black impressions. Used properly for jobs where requirements meet these limitations, the hectographic processes undeniably pay their way. Any effort, however, to make the hectograph take the place of any other duplicating method is not one of economy in any sense of the word.

DITTO DUPLICATION

It was in the year 1906 when a man employed in the shipping department of a large mail order house noticed that orders, tags, bills of lading and other shipping and invoice forms were being rewritten, not once but many times. He was appalled by the unnecessary waste of time and money and the inefficient manner of handling this important function. A pan of gelatin proved to be a practical answer to this problem. With it, all copies formerly rewritten could be reproduced more quickly and accurately.

For 100 years or more, the hectograph and its antecedents had been used for making copies. An original written with indelible ink was transferred to the gelatin surface and from that impression 25 to 50 copies were reproduced. The only improvement that had been made in that process was in 1882 when a German company manufactured the gelatin in long sheets wound in rolls which were used in a wooden box with suitable guides and ratchets. (6, page 43)

An Idea Takes Form: Crude as it was, this device seemed to have real possibilities. It was easier to make copies, and it provided much more gelatin surface on which to run copies than the gelatin pans afforded. Inspired by the idea, the mail order man quit his job and set about building a better duplicator. In an old building on the west side of Chicago, he developed his idea. This was the birth place of the first Ditto machine. By 1908, he had created the "Billograph," a sectional metal device with bedplate, side frames and carriage. It had plenty of faults, as in the case of most early inventions, and went through a period of development.

Sound Foundation: In the fall of 1909, J. A. Joy and T. W. Robinson, Sr., both successful business men, became interested in the Billograph Company. By 1918, the company was well established. (12, pages 26-28)

Direct Process: In the period following 1930, a new process appeared on the market, the liquid or spirit method of duplication. It was apparent that this process supplemented the gelatin process. It did many of the things that gelatin process could not do. The result was a line of machines which were far superior to any liquid process duplicators. New direct process supplies were soon developed, such as duplicating liquid, direct process carbon papers, masterset (combination carbon and master paper) and a special technique of printing through carbon and mastersets. (14, page 53)

Direct Process Duplicating Principle: There are no stencils to cut, no type to set, no mats to sensitize. The Ditto original is a sheet of paper. A deposit of dye is placed on the sheet by writing, typewriting or drawing thru Ditto direct process carbon paper. The carbon comes in four colors, purple, red, green and blue. All colors may be applied to the same original and all will reproduce in one simple operation.

The master or original, prepared in the same manner as you would write or type a letter, is ready for instant use. The master is then clamped in the duplicating machine and the copies are run. If only a few copies are run, the original may be filed and re-used over and over again until all of the dye deposit is exhausted.

The duplication of drawings in color is amazingly simple. Just draw on a sheet of paper through direct process carbon using any of the four colors available. The carbon copy becomes the original or master from which the copies are made.

Duplicating carbon paper, typewriter ribbons and pencils are available in four colors, purple, red, green, and blue. Fluid inks are provided in eight colors, purple, red, green, blue, black, yellow, brown, and orange. Any or all of them may be copied in one operation direct from the original writing or drawing. A master may combine typing with pencil or ink drawing and lettering. (31, pages 68-71)

Advantages: The advantages of the Ditto duplicating process are as follows;

1. Copies direct from original writing, typing or drawing.
2. Copies 4 colors in one operation.
3. Makes 100 or more copies per minute.
4. Produces 300 and more copies from each original.
5. Copies forms on any size paper until the maximum of the machine is reached.
6. Copies on varying weights of paper and card stock.
7. Originals may be re-used until entire ink supply is exhausted.
8. Delivers copies face up.
9. Requires only one turn of handle for each copy.

Disadvantages: Perhaps the greatest disadvantage of Ditto duplication is the tendency to fade over a period of time, therefore, this method could not be used for the making of permanent records.

It may be concluded that the importance of Ditto duplicating depends upon the individual using the equipment. A study of the physical properties should be supplemented by an "exploring" method used to become acquainted with duplication. The great secret of perfection in duplicating is continuous practice and a complete willingness to determine causes and results.

MIMEOGRAPH

Transferring an image by means of a stencil is a process handed down from the ages. Playing cards, silk prints, vases, labels, and picture books, are an example of the multitude of printed pieces produced by the ancients with the help of stencils and pigments. They are significant in that they indicate, by virtue of their long life, the tremendous part played by the stencil in the development of duplicating. A stencil is a sheet of some non-porous material so perforated that when a colored substance is allowed to penetrate through the perforations to a closely contacted surface, an image, identical to that marked on the stencil by the perforations, is left on the contacted surface. (7, page 55)

Early Limitations: Early and widespread use of the stencil method of reproduction had limitations. Large areas of reading matter were considered impractical for stencil duplication. Moreover, solid continuous lines presented difficulties. These two obstacles alone were enough to turn the early experimenters in the field of printing away from the stencil as a printing medium. It was not until modern business suddenly demanded an easy, fast, economical way of reproducing form letters that stencil duplicating came into its own. Once more necessity became the mother of invention. (30, pages 55-56)

<u>Electric</u> <u>Pen</u>: Thomas A. Edison's electric pen, introduced in 1875, was the first step in modern stencil duplicating. It consisted of a "pen" with an electrically vibrated needle point which left in its path a series of minute holes in the paper on which the operator was writing. Thus was made an autographic, handwritten, stencil from which as many as 5,000 copies, dependent upon the lasting qualities of the paper from which the stencil was made, could be produced. The "press" included in Edison's stencil process was simply a frame in which the stencil was held so that the ink from a felt roller passed over the stencil surface, could penetrate through the perforations to leave an impression of the stenciled matter on the paper beneath. It is estimated that at one time, about 60,000 of these electric pens were in use throughout the world. (7, pages 175-176) (24, page 339)

The fame of Edison's electric pen had not reached the ears of Albert Blade Dick, a young mid-western lumberman who rebelled at the waste of time and effort in copying daily price lists. The modern method of stencil duplicating might never have been discovered if A. B. Dick had been aware of Edison's duplicating device. As it was, after a long siege of unsuccessful experiments with many different ideas, most of them based on the stencil principle, chance finally took a hand in his efforts. Seated at his desk one day, the young inventor laid upon an ordinary flat file a piece of waxed paper, such as used to wrap candy, and casually drew an awl across it. Upon subsequent inspection of the paper, he discovered that the awl had left a path of tiny perforations. It was in 1884, after much experimenting that Mr. Dick finally had a file plate, a properly coated wax paper, and a stylus with which to write. With this equipment, he proceeded to turn out his price lists and form letters more easily and economically than could be done with Edison's electric pen.

It was in 1887, when Mr. Dick applied for a patent for his stencil process, that he ran across Mr. Edison's electric pen. When he took his idea to the great inventor, Mr. Edison was so impressed with the simplicity and economy of A. B. Dick's process that he agreed to permit its manufacture and sale and to allow his name to be associated with the stencil process. (7, page 176)

Company was Formed: A company was formed to make and sell machines and supplies for stencil duplicating, and a trade-mark was coined to identify its products. This was the word "Mimeograph," which was made by combining two Greek words, "mime" and "graph" with an "o" inserted for euphony. The stencil duplicating machines and supplies which A. B. Dick Company has sold under this trade-mark have become so widely known and used that the trade-mark "Mimeograph" like "Kodak" and other well known trade-marks, have become more widely known than the name of the manufacturer who owns the trade-mark.

There is little doubt that stencil duplicating in America owes its rapid and widespread growth to the Mimeograph machines and stencils as developed by the A. B. Dick Company. In recent years many different makes of stencil duplicators and other stencil duplicating equipment have been introduced both in America and abroad. In Europe a stencil duplicator called the "Cyclostyle" was introduced in the early Eighties, by D. Gestetner, but the development of the stencil process there was not as rapid as it was in America. Today, stencil duplicating throughout the world has reached a remarkable state of high quality and capabilities. (1, page 1)

Stencil Duplicating Today: Stencil duplicating today is a highly developed process. Unlike the major printing processes it is essentially individualized. Letterpress and offset-lithography were originally found only in the job-printing plant. Later, individualized equipment for the office was developed by adaption from the larger forms of those processes. Stencil duplicating, on the other hand, had its original basis in individualized duplicating. (7, page 177)

Stencil Sheet: Actually, the heart of the process is the stencil sheet. The duplicator is simply the machine to which this stencil is attached to transmit ink through the openings in the stencil to the paper, thereby leaving the desired impression. It brings stencil, paper, and ink together at the proper time.

The all-important stencil sheet is easily prepared by any of the following; the typewriter, a stylus and a special drawing board, a photographic process, or a special process of die-impression. Each of these is a contributory factor in making stencil duplicating a complete process. (1, pages 6-7)

Three Major Steps: There are three major steps, to consider in regard to the stencil process. They are; (1) planning the work, (2) preparing the machine, and (3) operating the machine. The job to be stencil-duplicated must follow all three operations.

Planning the Work: Since speed and low cost are prime factors in this process, special attention must be given, in planning, to the most efficient method of doing the job. If the copy is entirely typewritten matter, the typewriter is obviously the means of preparing the stencil sheet. Wrongly spaced and unattractive work, as well as waste due to ruined stencils, is prevented by carefully determining in advance just where the copy must be placed on the stencil sheet. Later this advance positioning shows its value in transmitting the image to its proper place on the paper, particularly helpful where close registration is desired.

Often typewritten work is not all that had to be considered in the planning. In stencil duplicating, as in the other processes, illustrations and rules play an important part. These, therefore, must be planned for. In any event, the complete copy that is to be put onto the stencil sheet is always carefully positioned before proceeding with actual stencil preparation. (2, pages 273-275)

Importance of Typewriter: Since by far the most of all type matter in stencil duplicating is typewritten, the typewriter becomes the typesetter of this process. The simplicity of this typing operation is one of the key factors to the success of the stencil process. It simply involves inserting the stencil sheet into a typewriter and typing the copy as though it were an ordinary letter. Inasmuch, as the stencil sheet consists of an extremely thin, fibrous sheet covered with a plastic chemical coating, the striking of the typewriter keys against the stencil sheet pushes the coating aside or presses it through, leaving the fibrous sheet exposed. This sheet is strong enough to hold the stencil sheet together and porous enough to allow the ink to pass through.

<u>Illustrative Portions of the Stencil</u>: There are two or three ways of making the illustrative portions of the stencil. One method, the most commonly used, is by means of a transparent drawing board, Fig. 9, and a stylus. By drawing on the stencil sheet with a metal stylus or pen the coating is pushed aside and through, as it is in typing, and an image is left that will allow ink to pass through to the paper. This stylus work is facilitated by the transparent drawing board which permits the tracing of pictures, drawings, and diagrams. Ruling, too, is accomplished readily by means of the drawing board and the T-square. (1, lesson 4)

In addition to this manual method, illustrative material can be exactly reproduced onto a stencil sheet by means of a photographic process. Most users of the stencil process have this done by some company especially equipped for this purpose; a few, however, have sufficient application to warrant installation of the necessary photographic equipment. There, also, are available photographically prepared illustrations all ready for use. This can be spliced into the stencil by a simple cutting and pasting process.

The final method, one that is of particular value in the duplication of filled-in forms and reports, is "stencil-die-impression." This method combines permanent headings, ruled forms or designs, with variable facts, figures, etc., in one duplicating operation. This is accomplished by having the permanent material impressed onto the stencil sheet by means of a metal die. The variable matter is then easily added by any of the regular stencilizing processes. The original application of this method provides for impressions of the permanent material onto a number of stencil sheets. Thus, it is unnecessary to reproduce the entire form whenever the variable material is added to complete the necessary information. (3, pages 338-389)

Color Work: Just a word should be said here in connection with color work in the stencil process. If two or more colors are used and if the different colored sections of copy are separated from each other by a blank space of at least on inch, all colors can be run at the same time. The stencil, therefore, is prepared just as if it were to be run in only one color. If, however, the colors are not adequately separated, a different stencil must be prepared for each conflicting color section. Later, the stencils will be run separately on the same impressive paper, thereby depositing their respective color images in proper position. Needless to say, these different sections of copy must be accurately positioned on their respective stencils so that each stencil as it leaves its image on the impression paper, fits into a well balanced page. (1, lessons 8 and 11) (12, pages 26-28)

Inking: The inking in the stencil process is different from any of the major processes in that the ink is applied from the "inside out" rather than from the outside, as in other processes. Located just above the path of the paper is a large cylinder with a perforated surface. Over this perforated surface is attached an ink pad. This pad is inked, when necessary, with liquid ink through the perforated surface from a reservoir inside the cylinder. Over the ink pad is stretched the stencil, so that in the duplicating process the ink can come through all the minute openings that have been made in the stencil. (30, page 64)

Transferring the Image: The actual duplicating, the transferring of the image to the paper, is, of course, the ultimate aim of the whole process. As the paper is fed into the paper "stops" in time with its arrival, the cylinder revolves and brings the top of the stencil down to meet the top of the paper. As the stop releases the paper and it moves forward, the cylinder continues to revolve, and the impression roller comes up from below the paper to push it up against the stencil on the cylinder. This is the actual duplicating. The pressure of the impression roller against the stencil and the ink pad beneath it squeezes just enough ink out of the pad through the openings in the stencil to deposit on the paper the image that has been stencilized. The process is completed when the entire image has been impressed on the paper and the finished copy is dropped into the receiving tray. (33, pages 292-294)

Stencil Duplicating in the School: Speed, economy, simplicity, satisfactory qualities, adaptability, all of these have been constantly in mind of those interested in, and responsible for, the development of stencil duplicating. A stencil can be prepared and 1,000 copies run from it in less than one hour. The cost of materials, equipment, and operator's time are relatively low as no part of the process requires technically or artistically trained operators. The process is not limited to one type of duplication, it has remarkable versatility; as good stencil process work compares favorably in quality with any of the other duplicating processes. Stencil duplicating can be carried on right in the school proper. The equipment takes up little space, and most of the newer machines are exceptionally quiet. (27, pages 92-94)

Limitations: Half-tones and large solid areas cannot be duplicated satisfactorily by means of a stencil. The stencil, too, although those of best quality are surprisingly durable, is rarely used for runs of over 5,000 copies. That is the principle reason for the general rule that stencil duplication's practical value begins at 10 copies and ends at 5,000. This does not mean the stencil process should never be used on long runs. Indeed, there have been cases where many more copies were run from one stencil. These are exceptions, and for the average user of stencil duplicating they are economically impractical.

It may be concluded that stencil duplicating by virtue of its origin, its development, and its very nature, is undoubtedly one of the important school duplicating processes. There are cases where the work is all of such nature or quantity that setting up the stencil process to handle it would be utterly uneconomical, in terms of time and results achieved. Many industrial arts instructors, however, find the unusual versatility, simplicity, and economy of the stencil process an irresistible recommendation.

Part B

BLUEPRINT

The method most commonly used to produce duplicate copies of original plans for the use of the construction engineer in the field, the workman in the shop, or for use in the drafting laboratory, is that of blueprinting.

History: In 1775 the principles of modern blueprinting were discovered in England, but it was sixty years before Sir John Herschel first applied those principles practically. It was one hundred years later that the process was introduced to the United States at the Centennial Exposition in 1876. For a process, as widely used as Blueprinting, to wait one hundred years for general use in America is an amazing thing. (14, page 7)

J. Norman Jensen's comments on the early history of blueprinting are as follows:

> In 1879, Silliman and Farnsworth of New York City were engaged as Architects for the Chemical Laboratory Building of Vassar College. This building had been donated to the college by the sons of Matthew Vassar, founder of Vassar College. Silliman and Farnsworth had been selected for this work because Mr. Silliman was also a chemist and familiar with laboratory requirements.
>
> Mr. Silliman brought from New York City three blueprints of the proposed laboratory building. They were a sensation in Poughkeepsie, N. Y., and well they might, as they were the first blueprints ever produced.
>
> Prior to 1879 copies of original plans had been made by tracing laboriously each set on tracing cloth. A fellow member of a chemical society in which Mr. Silliman was active discovered the formula for the blueprinting chemicals. No patents were obtained. Silliman and Farnsworth tried out the new formula at their first opportunity and brought the blueprints to Poughkeepsie.
>
> Blueprinting in those early days could hardly be called a fine art. The instructions which accompanied the formula stated that the chemical solution should be spread on the paper evenly with a sponge in a dark room. In applying this solution the blueprinter's hands were dyed as blue as Sis Hopkin's hair ribbon. In the winter time his troubles were worse. In making a blueprint the tracing and the prepared paper were placed in a frame exposed to the sunlight. After alternate washing and printing in cold water chapped the hands of the blueprinter so that great cracks appeared in his skin. To the aspirant for architectural fame and fortune hands which were blue and cracked were merely an incident in one's career. (21, page 355)

<u>The Principles</u>: Those early principles discovered in 1775 are ostensibly the same as those upon which blueprinting is based today. Light, either sun or electric, has a decided effect on a chemical compound known as ferro-prussiate; it turns the color from a place green to a deep blue. If a sheet of white paper is coated with a solution

of ferro-prussiate and is held so that only a portion of it is exposed to light, that exposed part will turn blue while the unexposed section remains its original color. Then, if the paper is washed in water which removes the unexposed solution, revealing the white paper, and fixes the exposed blue, a print is obtained in blue and white. This, then, is a blueprint. (44, page 9)

Direct Copying: To understand blueprinting is to understand in general the direct copying process. Blueprinting always requires the original material, be it a drawing or handwriting or text in type, to be on only one side of some translucent material.

For ordinary purposes, if the original is not satisfactory, a tracing can be very satisfactorily made on thin paper. Indeed, light weight bond papers are often used for this purpose, sometimes transparentized with a solution of some light oil mixture. Wherever greater accuracy, clearer print, and longer life of the tracing are required as for architectural drawings, a fine grade of linen, heavily sized, is usually used.

To insure a clear, satisfactory print this tracing should be carefully done. An opaque ink or heavy pencil is necessary; black is generally used, though orange and yellow are considered good. Blue and violet are usuable if enough Chinese white is added to build up their opacity. This last statement is true for practically any color. (37, page 329)

Folds, wrinkles, and water spots on the tracing will show up on the blueprint, so they are avoided. Rolling the tracing or preserving it flat to avoid wrinkles and creases, and working in a cool room to avoid moist hands are excellent trouble preventatives.

Once the tracing or translucent original is obtained, it is necessary to secure a piece of blueprint paper. For the average user of blueprints in the school, it is cheaper and handier to buy blueprint paper ready to use, though it can be made very easily by simply coating plain white paper with a ferro-prussiate solution. (35, pages 30A, 34A)

Types of Blueprint Paper: Blueprint paper is graded in physical weight from extra-thin through thin, medium thick, thick, to extra-thick. Extra-thin is used where light weight is essential as in mailing; medium-thick is not widely used; extra-thick is available wherever strength and durability are prime requisites of the finished print. As to the chemical coatings, which very widely according to the formula of the solutions used, their prime difference lies in their exposure-time requirements. These can be anywhere from 20 seconds to 4 to 5 minutes, even longer, though this is a rarity. As will be seen later, this coating, though important, is not the only time-determining element, as other factors may enter into the making of the print. (37, page

Making the Print: With sensitized paper in one hand and the tracing or translucent original in the other, it is time to bring the two together and to expose them to light. To do that, many different mechanisms have been developed.

Simplest of these is a small hard-wood frame with a clear glass front, a black felt pad equal in size to the glass, and detachable back. The tracing or translucent original is placed within the frame, ink or penciled side against the glass. The blueprint paper is placed on top of the tracing, sensitized side toward the original. The felt pad is laid over the blueprint paper, the back locked securely, and the glass front is then turned toward the sun or any other strong light. The material to be copied is held tightly in place, its inked or penciled parts allowing the light to reach the sensitized surface only through translucent areas.

Exposure Time: As noted before, exposure time varies according to several factors. Foremost is the solution used to sensitize the surface of the blueprint paper. Second, is the degree of brilliance and character of the light. Third, is the quality of print desired, inasmuch, as correct exposure brings out a deep, clear blue and sharp lines. An under-exposed print, though usually readable, may lose some detail and clarity.

Obviously, with so many variables, exposure time allowed by the operator becomes a matter of judgment as developed by experience. To supplement this, trial exposures on small pieces of blueprint paper may be made, until the correct exposure time is reached. After one print has been made satisfactorily, subsequent exposures may be made with the same amount of time, under those same conditions.

Developing the Print: After exposure, the print must be immersed in water, preferably running from the faucet. This washing removes the unexposed green portions of the coating and "fixes" or partially makes permanent the exposed blue. After being washed in clear water, the print should be placed in a bath of 1 to 3 per cent solution of potassium bichromate to "fix" and intensify the colored image. Let the print remain in this solution until it reaches the desired blue color and has well defined lines and type matter. After this, the print is washed once more in clean running water and finally hung up, or placed on a flat surface to dry.

Limitations: The age of the paper is a determining factor. The older the paper, the quicker it prints and the longer to wash; the fresher the paper, the slower it prints and the quicker to wash. A print which is applied by over-exposure may be restored by washing it in hydrogen peroxide.

Blueprint paper should be stored away from moisture, in a cool place. When using blueprint paper, the printing frame should be opened up and filled in a room, shaded from any bright light.

The equipment and materials used in blueprinting have been discussed in every detail, in the preceeding paragraphs. For school shop purposes, particular attention should be given to the fact that the blueprinting process, as an industrial arts subject, would require only a minimum of equipment and supplies. Most of the equipment can be purchased, if desired, at a very reasonable cost or could be made at almost no cost whatsoever, excepting for materials. According to the cost of equipment and materials, and to the service rendered by the process to the students, school and the community, the blueprinting process could be one of the more functional phases of the industrial arts program.

OZALID PRINTING

One of the new methods used to produce duplicate copies of original plans for the United States Government, the construction engineer, the research laboratory, the workman in the shop, or used in the drafting room, is that of Ozalid Printing.

What is Ozalid Printing? Ozalid is a reproduction process which produces positive prints direct from positive originals, and negative prints direct from negative originals. Thus, it is possible to make positive originals from drawings or typed material, which are positive originals, without an intermediate step on sharp, easy to read Ozalid prints with black, blue, or sepia lines on a white background. On the other hand, if the originals are negative Van Dykes, negative prints will be obtained and they will be as easy to read as blueprints or other negative reproductions. All Ozalid prints, in any color or on any material, are made in two quick steps: (1) exposure and (2) development. No baths or driers are used, consequently, Ozalid prints are truer-to-scale, and less inclined to curl. (40, page 170)

History: About 1921, the Ozalid process of printing was discovered by a monk, Father Kogel, who was a professor at Karlsruhe Technical Institute, in Germany. He produced a paper that, when sensitized with diazo compounds, exposed to an ultraviolet light, and then placed in a container with ammonia vapor, would yield a positive image.

The first Ozalid product, Ozalid M (Red Line on paper base) was produced in 1923, by Kalle and Company, of Germany. The material has not been altered since, and still forms some 50 per cent of the output of Ozalid materials. The only disadvantage was that the background became slightly yellow on prolonged storage in the dark, although prints kept well in the light.

During the nineteen-twenties, General Aniline and Film Corporation of United States, passed under the control and domination of I. G.

Farben, the German Chemical Trust. With this shift of control there became available scientific and technical knowledge, and the Farben research facilities which assisted General Aniline to gain a top-rank position in its field. Productive capacity was greatly increased, a fact which proved a powerful boomerrang against its former owners during the war.

Shortly after Pearl Harbor, General Aniline was seized by the United States Alien Property Custodian, the most valuable single property to come into the Custodian's hands. The management was entrusted to American directors, with a directive to give fullest support to the war effort. The directive further stated that the company would never again return to German ownership, and that the stock would be sold to American Investors.

In the middle thirties Ozalid announced its process, in the United States, referring to it as a new, simplified and versatile method of reproducing engineering and architectural drawing. (Pamphlet, The Making of an American Company, General Aniline and Film Corporation)

Ozalid Chemistry: Many have wondered why Ozalid is so versatile, why positive prints can be made, in so many different colors, on so many different materials?

The answer lies in two facts; (1) Ozalid sensitizes all of its materials with a combination of unique Diazo salts and couplers. The Diazoes (a) are light sensitive; (b) react with the couplers in the presence of the Ozalid dry-developing agent (heated aqua ammonia vapors) to form a permanent dye image. The color of the dye image depends upon the combination of the Diazo salts and the couplers used. (2) Practically any type of material can thus be sensitized and subsequently used in shop made equipment, since chemical baths and driers and all other print distorting influences have been eliminated.

When the original and the Ozalid sensitized paper pass through the printer or exposed to the sun's rays in the sun frame, the light rays penetrate the original and strike all of the sensitized surface which is unprotected (without lines, numbers, or other figures on the original shielding it) and causes a decomposition. It is decomposed, because Diazo salts in the presence of water, which actually exists in sufficient quantity in the sensitized material, are changed into invisible compounds when exposed to light on the correct spectral composition.

If a print is inspected closely after it has been exposed, it will be noticed that only an exact facsimile of the original is present, in weak yellow detail, and that the area which was exposed is now colorless.

When the Ozalid print is conveyed to the developing tank, heated ammonia vapors will arise and contact the yellow lines transforming them into permanent dye images. The color thus developed being black, blue, red, or sepia, depending upon the type of Ozalid material used. The chemical explanation as to why these yellow lines become so transformed lies in the fact that Diazo salts react with their couplers in the presence of an alkali, heated ammonia fumes to form permanent dye images of the original's lines or characters.

By selection of the proper Diazonium salt and coupler, practically any color of the rainbow can be formed. So far, however, only a relatively small number of these have been used commercially.

From the above description, it is easily observed why Ozalid prints have a tinted background if too opaque an original is used, or if insufficient exposure time is allowed, as all of the undesired sensitized coating was not eliminated. Therefore, the density is the greatest where the least light has struck the sensitized surface.

Incidentally, the reaction of Ozalid materials to light is just the opposite of the reaction present in photography. Here the greatest density will result from a long exposure to light, and conversely, shortened exposure will produce little or no density. In other words, Ozalid Diazo salts react in just the opposite manner as the silver halide-gelatin combinations with which photographic papers are coated.

In development, too, the Ozalid materials react in exactly the opposite fashion They are developed dry, in seconds, by ammonia vapors, whereas, photographic materials require the use of developing and fixing solutions, washing and drying, all of which involves much more time and effort. (36, pages 4, 41)

<u>Storing Ozalid Sensitized Materials</u>: The life of Ozalid sensitized materials, like that of blueprint or photographic materials, depends to a great extent upon the manner in which they are stored. It is a good practice never to overstock Ozalid materials, that is, never order more than a month's supply at one time. This will insure the use of fresh material at all times.

Ozalid materials, when received, should be stored in a room which is reasonably cool and which has as low a moisture content as is possible. Moisture in the air has a tendency to increase the printing speeds of the papers.

All Ozalid materials are wrapped in heavy opaque paper and no precaution against exposure need be taken while they remain in the wrapper. Of course, when they have been removed, prolonged exposure to day light or artificial light will deteriorate the sensitized coatings.

An ideal storage room for Ozalid materials would be one that is air-conditioned between 60 and 70 degrees F., and which has as low a moisture content as 50 per cent relative humidity. Another reason why moisture is not to be desired lies in the fact that the longevity of the papers will be decreased, and the papers will couple more readily. Never bring papers directly from a very low to a very high temperature, that is, from 0 to 80 degrees F. Make the change gradually, so that moisture cannot form inside the wrapper. A final caution should be added, never store Ozalid materials where they may be contacted by ammonia vapors. (36, page 40)

Ozalid Translucent Papers: The Ozalid process is predicated on the use of translucent originals. Ozalid is actually a means of simplifying paper work, of speeding production, of saving time and work. The accomplishment of these functions is conditioned in a large degree by the kind of material or original paper used, the quality, and the speed. The cost of Ozalid reproductions are all affected by the selection of the original. There is no one paper suitable for all applications. In some cases printing speed is the most important consideration, in others, paper cost is a prime concern, or perhaps acceptance of pencil, ink, or typing may be the determining factor. There are other qualities which may be desired, erasability, permanence, uniformity from lot to lot, appearance and acceptability of printed, stenciled or lithographed impressions. All of these things should be considered in relation to the job at hand. (36, page 25)

Ozalid Intermediate Materials: Ozalid intermediate prints, made from Ozalid translucent papers, are so called because they can be substituted for valuable originals in print production, thereby providing permanent insurance. When intermediate masters are printed, the originals can be filed away, safe from loss, wear, and tear. There is no limit to the number of intermediate masters that may be printed from an original. (36, page 11)

Ozalid Foils for Composite Prints; Ozalid transparent foils, besides being used as intermediates, can be employed to make composite prints in the following manner. Separate design details are drawn, each on an individual sheet of translucent paper, exposed and developed. Then, it is possible to overlay these prints in any combination or in any position and make prints showing composite details as desired. Thus, it is possible to make prints which show heating, plumbing, electrical, airconditioning layouts, either separately or combined. (36, pages 15-16)

Ozalid Accessories: Ozalid accessories add to the scope and effectiveness of print making operations, and in some cases making possible additional, time-saving uses of time and materials.

Corrector fluid can be used to remove obsolete lines and details from all Ozalid intermediate prints. It is then possible to add the new design right to the intermediate, and use this corrected intermediate to produce subsequent prints.

Opaque typewriter ribbons have been developed that possess all of the qualities needed to produce good typed originals for Ozalid reproduction. A special effort has been made to make this ribbon suitable preparation of Ozalid originals and for normal typing requirements. These ribbons are made with a special black ink which blocks ultraviolet light, and produces a typed copy of maximum actinic opacity. A high grade fabric is used, insuring sharp clean impressions. The ink carrying vehicle is formulated to prevent feathering on any kind of paper, and to minimize smudge.

Ozalid transparentizing solution expands the usefulness of Ozalid printing, by making possible the reproduction of opaque papers. Ozalid transparentizing solution is applied to the back of the opaque sheet, usually with a cotton pad. It should not be applied to the front of the sheet for it will smear pencil, ink, or typing. The solution has a surprisingly efficient transparentizing action, which even actually works well on fairly heavy ledger stock. Of course, it is not possible to successfully transparentize all papers, for example, those which are printed on two sides or which are of a yellow, orange, or brown color.

Ozalid masking agent is an effective and practical means of neutralizing ammonia odor. It is a blue fluid which is added to ammonia in the proportion of one fluid ounce to one gallon. When it is used, any ammonia vapors which may escape into the room during developing, and slight traces of ammonia which may cling to prints immediately after delivery from the developer are completely masked. Ozalid masking agent is especially recommended for use in offices, drafting, and similar rooms where activities other than printmaking are carried on. (36, pages 26-27)

Preparing Tracings in the Drafting Room: The purpose of every drawing is ultimately to allow workers in the shop, the laboratory, assembly lines, or in the field to build according to the specifications listed thereon. In just about every case, many copies of the original are made, the quality of each depending, to a great extent, upon the quality of the original drawing. Therefore, it is advisable for the draftsman to keep a few things in mind when preparing an original, for these will eliminate inconveniences along the way and not waste the time and labor represented in every drawing.

Actually, all the draftsman needs to remember is that prints must be made from the tracing. If he does this, he will use a translucent tracing paper of good quality and he will make his lines as opaque as possible.

The pencil used is also an important factor which deserves consideration. Research has found that draftsmen generally prefer a 2H or 3H pencil for lines and either an H or 2H for lettering. Using these pencils, better prints will be secured. Some types of tracing cloth takes graphite more readily than paper does, and in some cases 4H and 5H pencils can then be used. (36, page 30)

Preparing Tracings in the Office: Essentially, the standards are the same for the office as for the drafing room. The best possible prints will be secured from originals which are translucent and have opaque characters, whether drawn, typed, or printed.

With the right type of tracing paper, the typist need only remember to produce opaque figures when contact prints are desired. If a large number of prints are to be made, and exceptionally fine quality is desired, the best and most practical method to follow is to carbon-back the original copy. This simply means that the typist reverses the carbon paper, that is, has the inked side facing the sheet which is being typed. This produces opaque images on the reverse side as well as on the front side, and when Ozalid black-line prints are made, they will look like the typed originals.

It is recommended that a hard carbon paper be employed when carbon-backing, for it will produce images of maximum density. Carbon paper is relatively inexpensive and it is recommended that the sheets employed be used only a few times for carbon-backing purposes. After this, they can be used for the normal length of time in preparing ordinary carbon copies for material not intended for reproduction. (36, page 31)

Printing: The printing or exposure is done in the same manner as blueprinting. When the paper is exposed to light, the rays cause a chemical reaction to take place on the exposed area. It can be said that the chemical reaction of the exposed area disappears and the color of the paper reverts back to its original white color. The part under the lines drawn on the tracing retains the chemical with which the paper is coated, because the light did not penetrate and cause the chemical reaction previously mentioned. It is this remaining chemical that produces the dark line when the print is subjected to the developing medium.

The time of exposure in a sun frame is determined by a number of factors, namely, the time of day, the length of day, dust in the air, and cloudy sky. When a number of prints are to be made, it is desirable to cut a piece of printing paper into small pieces and test until a desirable time is found. Taking the above factors into consideration, and the various speeds of printing paper, the printing time will range from thirty seconds to five minutes.

The aim of the Ozalid user should be the reproducing of a print on any type of sensitized material which will have a maximum contrast between the line detail and background. In other words, have the darkest lines on the whitest background.

In the Ozalid process, the standards for underexposure and overexposure are the direct opposite of photographic standards. For Ozalid materials will have the greatest density where the least light has struck the sensitized layer, whereas silver halide photographic materials have maximum density only when given complete exposure. Thus, underexposed Ozalid prints will have considerable background and the line detail, while being strong, provides little contrast. On the other hand, Ozalid prints which are overexposed, will have a white background, but weak line detail. The correct exposure lies between these two points. When the average originals (prepared on translucent material and having opaque images) are used, no difficulty should be experienced in achieving the best results. (36, pages 34-35)

<u>Development of Ozalid Prints with Ammonia</u>: The development of Ozalid and similar type paper is a one step process. After the paper is exposed, it is removed from the sun frame or printing device and is ready for the developing apparatus. The writer has found from a series of tests, that the period of time between removal from the printing device and the placing of the print in the developing apparatus is not critical. Tests were run on the Ozalid paper, where sensitized paper was exposed and then placed face or exposed side up in a room where the shades were drawn to exclude the afternoon sun. After being exposed to the light of the shaded room for four hours, the print was placed in the developing apparatus and an excellent print was

secured. Results from this experiment leads the writer to make the practice of printing a large number of prints, stacking them as they are removed from the printer and then developing all the prints at one time. Tests were run on how close together the prints could be placed in the developer and yet achieve good results. It was found that a 11 by 17 sheet of exposed paper could be rolled in a cylinder one inch in diameter, exposed side in, secured with rubber bands, could then be placed in the developer, and an excellent print secured.

As explained in a previous paragraph, the developing agent of Ozalid is a 28 per cent aqua ammonia. Do not use waste ammonia or household ammonia, as these solutions are too weak. The warming up of the developer should start some five or ten minutes before developing is started. This is accomplished by placing the ammonia, perhaps one-half to one ounce, in a small metal container which is placed inside the developer. Better results were achieved when a piece of cotton was used to absorb the greater portion of the ammonia. The ammonia must be heated, from an outside source, to insure maximum efficiency. An incandescent lamp bulb of 200 watts makes a desirable heating unit. Heated ammonia vapor is approximately one-half the weight of air, which makes necessary the use of a telescoping top to the developer to avoid loss of the vapor when the developer is opened. As the telescoping top is removed, the ammonia vapor will ascend and will remain contained as long as the top is held in the vertical position. It is well to move the top up and down rapidly a few times, to thoroughly mix the air and ammonia vapor within the developer.

The period of developing depends upon the heat of the ammonia vapor, the amount of vapor in the developer, and the accumulated moisture. Under ideal conditions, the development of the prints takes place instantly. However, no damage to the print is incured if allowed to remain in the developer for several minutes or perhaps even longer. If, on removing the print, the printing has a green cast it is an indication that the print is underdeveloped. The print should then be placed inside the developer and exposed to the ammonia fumes for a longer period of time. Excessive moisture in the developer can be noticed by the dampness of the paper and the extended length of developing time. The moisture may accumulate, for at least, the following three conditions; (1) too weak a solution of ammonia, (2) using the ammonia for too long a period, and (3) heating up and cooling off the developer during the developing period. A small amount of moisture can be absorbed by placing paper towels inside the developer, otherwise the developer should be cooled off, cleaned and dried thoroughly, then start the process over again.

A word of caution should be added. If the hands of the operator are exposed to the ammonia fumes for too great a length of time, the outer skin dries and scales. This can be avoided by removing the developed prints hastily with a wire tong.

It may be concluded that Ozalid printing is undoubtedly one of the most important of the school duplicating processes. For school use, the Ozalid process requires only a minimum of equipment and supplies. The equipment may be constructed in the school shop, at the least possible cost. The print is easy to read, the paper is durable, and penciled, inked, or typed additions or corrections may be easily added.

<u>Future Possibilities with Ozalid:</u> Much work has been done to

produce a copying paper that can be developed by means of heat only. Description of this kind of coated paper may be found in an early Dutch patent. According to this patent the coating solution contains;

1. Diazo compound of a slack coupling capacity, that is, an aminodiazo compound.
2. A coupling compound.
3. A salt combined of a strong base (sodium or potassium) with a weak acid. The acid should be colatile when heated to high degrees.

After coating, the drying of the paper must be carried through very cautiously to avoid discoloring of the background. When papers of this kind are exposed to light, the diazo compound is bound to fade on those portions of the copy which are not screened from the light by the dark parts of the tracing. At the unexposed portion of the coated surface, formation of the dyestuff will take place by heating, that is, by using a flat-iron yielding thus a positive copy from a positive tracing. Formation of the dyestuff is obtained in the following manner; when heated, the above mentioned salt will split up, setting free the alkaline base, while the colative acid evaporates. The free alkaline effects the coupling action between diazo compound and component. (38, pages 1-3)

Results: Results gained from the above experimental work, and similar projects are very interesting, but not encouraging as far as exploitation of the method on a big commercial scale is concerned. This might be best explained by a comparison of its advantages and disadvantages.

Advantages: The only important advantage, of course, consists in avoiding the disagreeable influence of ammonia vapors while developing.

Disadvantages of the New Process: Some of the disadvantages of the new process are:

Diazosulphonates require considerable longer time to fade when exposed to light, than the usual diazo compounds. The time of exposure of a paper manufactured according to the best formula worked out for heat development up to now, exceeds the requirement for Ozalid TS by about 100 per cent. The light has the twofold task of transforming the sulphonate into a diazo compound first, and of decomposing the latter into a colorless phenol afterwards. Thence, the prolonged time of exposure.

It is common knowledge among experts in the art of light printing that highly dried copying papers tend to become brittle, especially in winter, when used in heated rooms. Now, it is indispensable to carefully dry the papers designed for heat development, preferably at a temperature of about 110 degrees C. The amount of water incorporated in the paper should be limited to 2 to 3 per cent. Moisture increases the disposition of premature coupling. On the other hand, the drying process increases the disposition of the papers to become brittle. What has been said for the unexposed paper applies all the more to the finished print which has to undergo a second heat treatment during development. It became evident that sufficient development will take place only at a minimum temperature of 180 degrees C.

Storing of these papers before use requires special precautions. The usual packing material, such as wax paper or tar paper does not warrant safe protection against premature coupling. Small bags containing water-absorbing chemicals have to be incorporated in a tinplate container together with the paper roll. Silicate has proved satisfactory for this purpose. By means of this device, a keeping quality of several months is obtained. But this statement does not imply that this keeping quality may always be expected. The paper will sometimes deteriorate from unknown causes.

In 1935, a sample of this paper, manufactured in Kalle and Co. Laboratory, in Germany, was forwarded to the Ozalid Corporation, in United States. The paper did not survive the Atlantic trip, showing premature coupling when it was tested in United States.

It will be necessary to construct new machines to replace the machines especially designed for ammonia development. No engineering work has been done for this purpose to date, except in a small apparatus for laboratory use, consisting of a metal cylinder, fitted with electrical heating, and with small guide rollers. This apparatus is only applicable for small sized prints. (18, pages 1-38) (38, pages 3-10)

Summing up the available information on heat development of Ozalid paper will lead to the conclusion that the processes of dry development, without ammonia, have not been satisfactorily perfected at this time.

THE BW PROCESS

The Bruning BW prints are exact "positive" copies or duplicates of an original or master copy that has been either drawn, printed, typed or written on translucent or transparent material. The BW process of reproduction is by no means new. It has been used for years in engineering departments and drafting rooms to produce positive copies of engineering drawings, specifications, charts, plats, maps, etc. The drafting instructor can find equally as many uses for this type of reproduction paper. BW prints are easy to read and to check, with black or colored lines on a white background. They are exact duplicates of the original copy.

History: The BW process has grown out of the dyeing industry. Green, Cross and Bevan in 1890 first prepared a printed cloth by impregnating it with diazotised Primulin, exposing under a pattern, and then coupling with azo dyestuff components. A few years later they used this same method in preparing the first diazotype print.

It was not until the late teens and early twenties of the twentieth century that this process first became commercially available. Numerous technical difficulties stood in the way, even at that time, such as poor keeping qualities of the paper, light fading of the image and yellowing of the backgrounds. Companies in Germany and Holland were active in developing two somewhat different types of diazotype processes. The BW process was developed by Van der Grinten in Holland and was introduced by the Bruning Company, into United States, in the year of 1930.

BW Chemistry: The category into which the BW process falls is called the diazotype, or direct printing process. It is based upon the principle that certain chemical compounds known as diazo compounds can; (1) be decomposed by ultraviolet light, and (2) combine with phenolic azo dyestuff coupling components to form insoluble dyes.

The BW process is a light-sensitive process by which positive copies can be made of anything drawn, typed, or printed on a transparent, translucent or opaque paper, film, or cloth. These copies are produced directly with only one exposure and, following that, moistening of the surface with a developing solution. BW products consists of a base such as paper, cloth, or film, coated with a solution containing the diazo compound, along with other chemicals such as acid buffers, anti-oxidants, and stabilizers. These products are relatively insensitive to artificial, incandescent light, or indoor daylight, so may be handled under such conditions with safety for a reasonable length of time.

When the coating is brought in contact with the developing solution containing the coupling agent, a dye is formed. However, when this coating is exposed to light, the diazo compound is decomposed and is no longer capable of forming a dye.

Exposure of Sensitized Paper: The mechanics of exposure are as simple as that for blueprints or the Ozalid process previously described. When the coated or sensitized surface is exposed to a strong actinic light, a chemical change takes place. The sensitizing solution disappears, leaving the surface of the paper white, with the exception of the drawn, printed, typed or written matter appearing on the original copy which acts as a shield or mask for the light. The light, unable to penetrate this portion of the original, leaves an exact replica of the image on the sensitized paper, formed by the remaining BW solution. This operation is performed in a matter of seconds, and the exposed medium is now ready to be developed.

Development of Print: The exposed sensitized paper can easily be developed by coating the back of the print with a solution of BW developer, using a sponge. It is possible to coat the back of the paper evenly by passing the exposed paper between rollers, the lower roller carrying the BW developer from container to the back of the paper. The developer solution transforms the faint image on the exposed medium to an exact duplicate of the original copy, that is, a positive print. The entire printing and developing operation may be accomplished in a very short time. The process is pleasant, simple, clean, and odorless. (Information on the Bruning BW process furnished the writer of this thesis, by the Charles Bruning Company, of New York.)

BROWN OR SOLAR PRINT PAPERS

Brown Print Paper is also known as Negative Paper or Solar Print Paper. The most widely used name, however, is Van Dyke Paper, which is a Dietzgen trade name, and has been ever since Dietzgen introduced the brown print process in this country. This is coated usually on light weight paper of 100 per cent rag stock and is obtained in any of the following weights; 12 lb., 14 lb., and 16 lb., and occasionally in 24 lb.

Formula: The formula, which is also secret, has silver as its base, and this is one of the reasons that the keeping qualities are not as great as compared with blueprint paper. If kept too long, or if the printed sheet is not washed thoroughly, the paper has a tendency to become brittle.

Printing Procedure: The printing procedure is the same as blueprinting, except that it usually is slower. The developing, however, is different, in that Van Dyke salts are used to "fix" and set the print after it has its first clear water wash. Hypotassium of Soda is also commonly used for this paper for the same purpose. After the fixing salts are applied, the print is washed again in clear water.

If the original is positive, such as a regular tracing, the resultant brown print will be a negative; that is, white lines against a dark Van Dyke brown background. If a brown print positive is desired, a negative is used as the subject of medium. In this way, the resultant print will be dark Van Dyke brown lines against a white background. The Van Dyke brown is opaque, and therefore brown print positives can also be used like an original tracing for making other prints. The brown print, or Solar process is also available, which is pretransparentized with an oil solution. Pretransparentized negative paper is usually used where a great number of prints are to be made from the negative and speed is a desirable factor. (Information on the Van Dyke process furnished the writer of this thesis, by the Eugene Dietzgen Company, of Chicago Illinois)

Conclusion: In summarizing this chapter on reproduction and duplication, the writer has put forth an effort to familiarize the reader with a few of the important processes. An impartial discussion and explanation of each process from the history down to present day practical use in the school laboratory has been made.

CHAPTER III

DRAFTING TEACHING AIDS

The individual who understands how learning takes place recognizes the importance of the sense of sight to the learning process. The learning situation which brings into play the greatest number of senses is likely to be the most effective. It is human to learn more through the sense of sight, than through any of the other senses. The student who hears a particular mechanism explained, sees how it operates, and then actually operates it, is participating actively in a situation favorable to economical learning. Visual aids enable the instructor to make excellent use of the important sense of sight in many and varying learning situations.

The devices illustrated and described in this chapter attempt to present to the drafting instructor a few of the visual mechanical aids that may be used in presenting the subject of drafting. The aids should be used only when they will assist the instructor in presenting a lesson. If the aid is displayed before needed, the students are likely to concentrate their attention on that particular aid, rather than upon what the instructor is saying or doing. In other words, the aid should not be called to the attention of the class until the stage is reached in the lesson where it will clarify certain points being taught by the teacher.

Part A

SEATING CHART

A seating chart, Fig. 1, is provided to accompany the plan of the

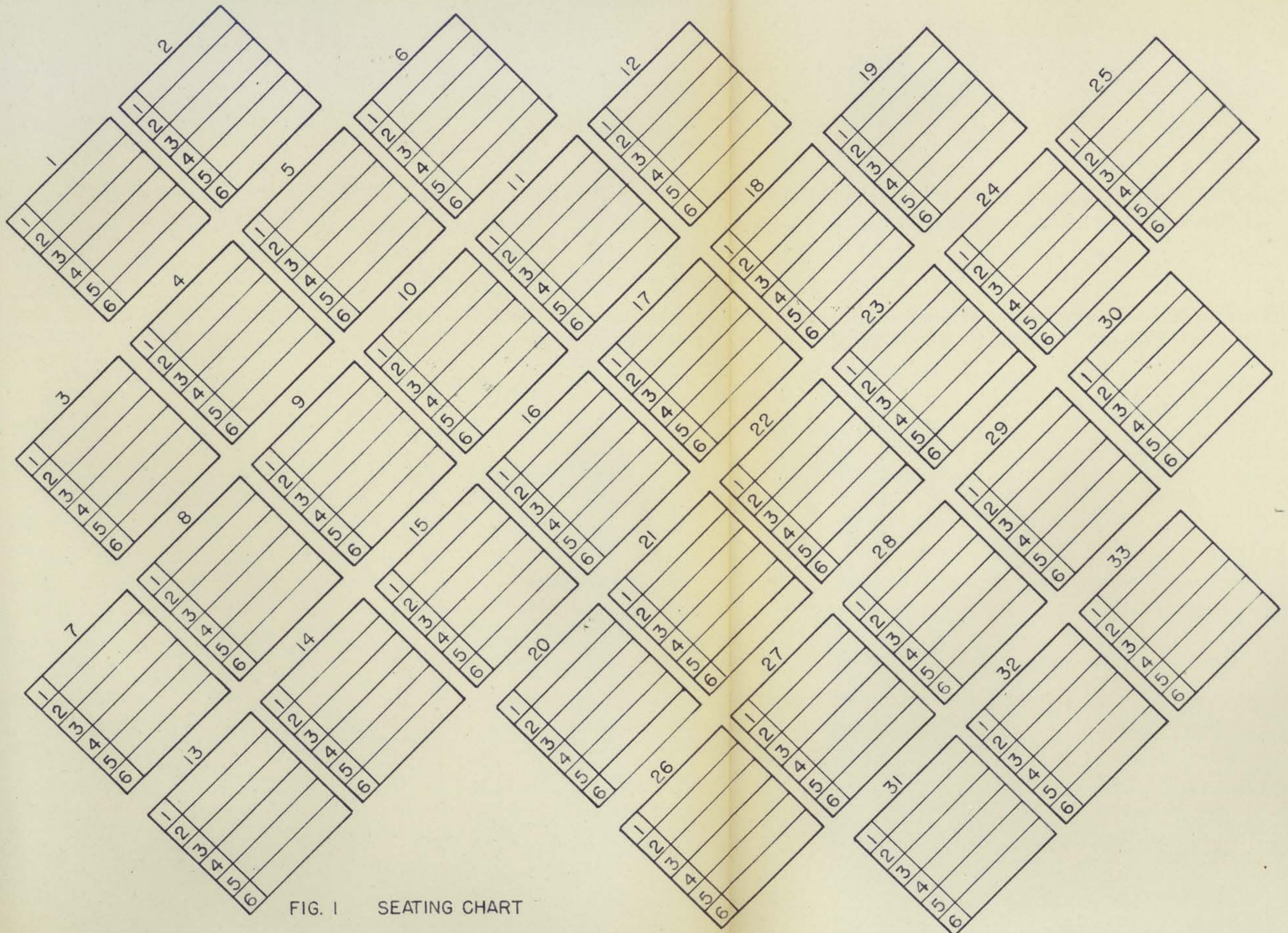


FIG. 1 SEATING CHART

drafting room, chapter 4, Fig. 12. The instructor's table could have a recess in the top, at a convenient location, to provide a place for the seating chart. Over the chart, a piece of double strength glass could be placed, bringing the surface of the glass even with the surface of the table top.

There are at least three purposes that the seating chart could justify; (1) assist the instructor in learning the names of the students, (2) provide a quick easy check on class attendance, and (3) aid a substitute instructor in the administration of the drafting room.

Part B

STUDENT PERSONNEL ORGANIZATION

As the areas of activities presented in the industrial arts laboratory have increased in number and scope, it has been expedient for the instructor to assign many of the clerical, preparatory, maintenance, and general routine duties to the students. This plan which has been organized in many ways, is generally referred to as a student personnel organization.

Valuable Experience: Pupils can receive valuable experience through participation in such a plan. Some of the basic values derived from a carefully planned organization are as follows; (1) broadens pupil development, (2) increases interest in work, (3) relieves the instructor of routine work and allows more time for instruction, and (4) shows the student the value of responsibility.

Student personnel organizations may vary according to many conditions that prevail in the laboratory, such as the number in class, kind of equipment, areas of work, and age of the students. An effective and worth-while organization calls for careful planning on the part of the instructor. Because of many variables that exist, no one plan could possibly fill all situations.

Organization of Students: In handling large classes and keeping a neat orderly laboratory, it becomes necessary for the instructor to establish an organization to assist him. The organization is composed of students from the class in which they are enrolled. They can assist the instructor in caring for the equipment, supplies, and help guard against accident hazards. To carry this program on effectively, it is necessary to install an organization whereby the instructor becomes the executive. Under him are foremen assigned to certain definite and specific responsibilities.

In setting up a personnel organization it must be explained to the students in detail the purpose, their duties, and the advantages of such a system. Too many instructors make the mistake of never explaining the program and making the students feel they are nothing more than a janitor or custodian for a portion of the period. When the organization is first introduced to the students it should be pointed out, that when they are given supervisory responsibilities, that these responsibilities serve as a means for giving them the finest type of training in the art of leadership and cooperation. It also acquaints them with what it means to be a good follower in order that the whole organization may function smoothly and efficiently.

There have been several different types of shop organizations tried, and, no doubt, each have their good points as well as their weak points. Too many times the instructor has used one system so long that he "follows the old groove," never realizing there could be much improvement made in the method. Others lack the initiative to try and work out a new and better method.

Explanation of Class Enrollment and Responsibility Board: At the first shop meeting this method should be explained and the general and assistant foreman should be elected by the students. There are two reasons for allowing the students to elect their foreman with the approval of the teacher; (1) they feel like they have taken part in the class organization, and (2) the students will usually pick a general foreman with whom they think they can work. Moreover, they will know him as "man to man" much better than the instructor does.

The general foreman is the coordinator between the pupil and the instructor. His duties as general foreman are many, and he has the greatest responsibility of all the students in the shop organization. He must check on the helpers under him to see if their work is complete and done correctly. He is to take the place of the instructor in event the instructor must be out of the room for a short time. He can also stop many of the discipline problems before they reach the instructor, or find the cause of any disturbance during the class period. He is elected for one semester, but may be replaced at any time the instructor deems it advisable. The assistant foreman is a helper to the general foreman and is elected for the same period of time. The number of daily tasks assigned the remainer of the students in the class depends upon the number of work stations there are in the laboratory.

There is one column, Fig. 2, for every class period and each student enrolled in the class has his name card block. On this block the following information is found; name, work station number, date started,

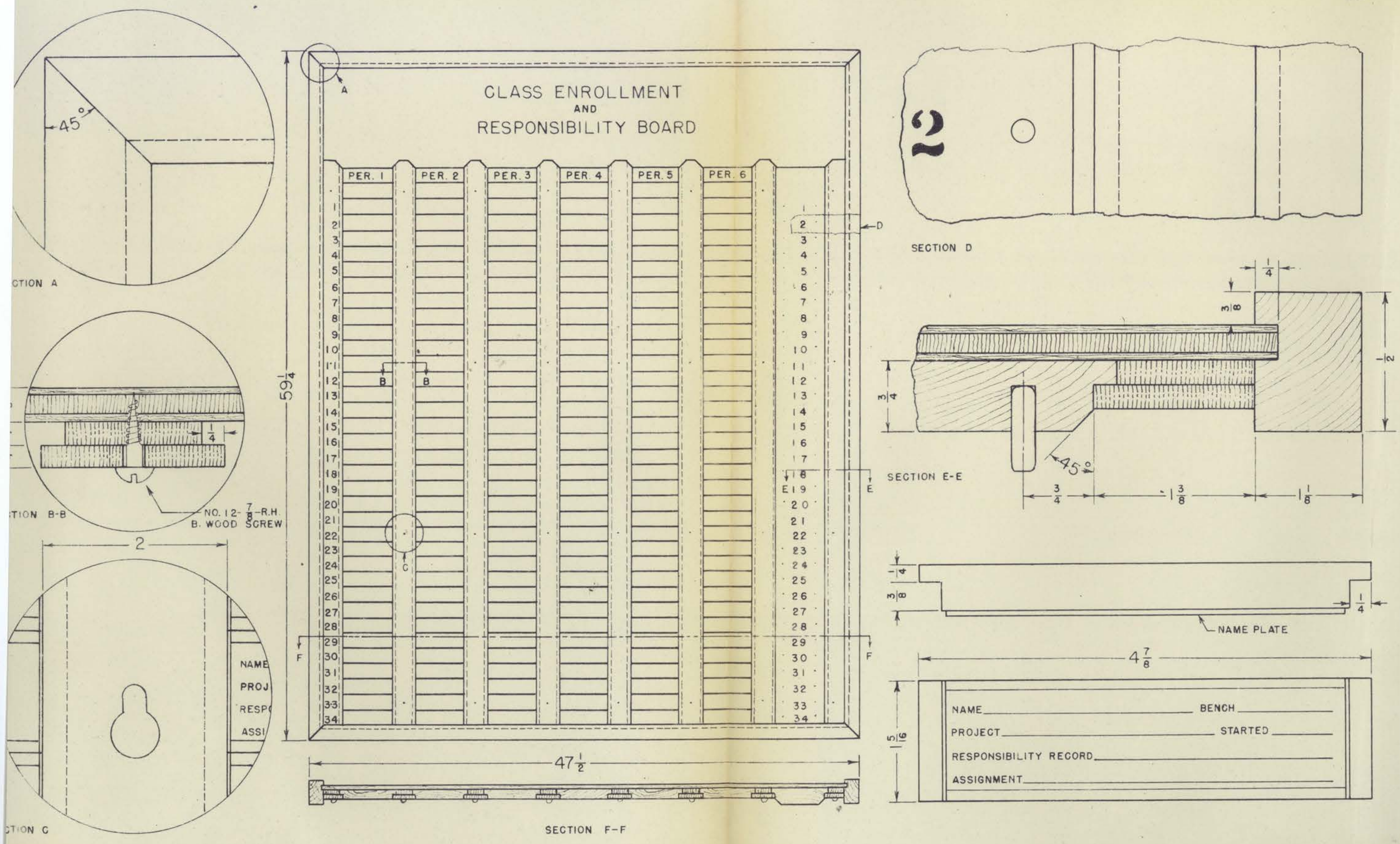


FIG. 2 CLASS ENROLLMENT AND RESPONSIBILITY BOARD SCALE 1/8" = 1"

responsibility record, and special assignments. At the end of the week, the block with the last name in the column is removed and inserted below the second block from the top while the others below slide down. The reason for putting this block in the third from the top, is due to the fact that the general and assistant foreman remain on the two top blocks. To the right of their name, printed on drafting tape, will be found their weekly work station to keep in a neat and orderly manner. If there are more students in the class than there are work stations, it is well to leave some blanks evenly spaced along the board so some weeks a student will not have a station to supervise.

A method of familiarizing the new officers with their duties is desirable. Most instructors will feel that it is valuable for the student, who just previously held the station, to spend some time instructing or assisting the student newly assigned to the station. This instruction would take place on the day the organization is rotated, or previous to that day.

When using the "Class Enrollment and Responsibility Board," the responsibility of a student starts as soon as he enters the laboratory by checking himself in on the attendance board. This represents the time clock of industry. The attendance column is found in the last row to the right, of the board, or in column seven. The attendance is taken in the following manner; each goes by the number of the work station which is assigned to him. By each number is a removable peg. When the students enter the drafting room, all the pegs will be either to the left or right of their number. To check in, they merely move their own and no other peg to the opposite side of their number. By this means the instructor or time keeper can very easily discover who is absent by checking the pegs that have not been moved to the correct side.

Every instructor will find it necessary to modify the use of the "Responsibility and Attendance Board" to meet his own particular needs. If time can be arranged, it is suggested that the instructor and foremen meet every two weeks to discuss, in privacy, problems that have arisen. This conference affords opportunity to develop and train the foremen in cooperation and leadership, which is very important to the success of the industrial arts department.

Part C

RECORD OF CLASS ATTENDANCE AND PARTICIPATION

An individual record should be kept of the progress of each member of a drafting class. A busy instructor cannot hope to keep in mind the status of progress of each individual of a class, or the value of each exercise or piece of work completed. The simplest way to keep a record of progress is to make use of a chart, Fig. 3, designed for that purpose. Across the top of the chart, the names of the exercises, operations, and jobs are recorded. As indicated on the drawing that accompanies this article, the names of the class members are recorded on the horizontal lines to the left of the checking columns. Charts may be made up in quantities in the blank form and filled in to suit the need of the individual class. The instructor must have a system of marks to indicate what progress the student is making.

Recording: Recording of progress on a chart according to units of instruction might appear to be a difficult task. Progress must be

COURSE NO. ____________
SUBJECT ____________
____
SEMESTER ____________
YEAR ____________
INSTRUCTOR
____

6 WEEKS	12 WEEKS	AVERAGE TEST	AVER. PROBLEM	FINAL TEST	FINAL GRADE			RECORD OF CLASS ATTENDANCE AND PARTICIPATION																											
SPEC. GRADES						NAME		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
						1																													
						2																													
						3																													
						4																													
						5																													
						6																													
						7																													
						8																													
						9																													
						10																													
						11																													
						12																													
						13																													
						14																													
						15																													
						16																													
						17																													
						18																													
						19																													
						20																													
						21																													

FIG. 3

recorded, however, and the recording should be based on mastery of fundamentals. The students should be checked on their ability to do what the instructor has taught them. At any point during the semester, comparisons may be made to determine individual grades and standing of students in the class.

The instructor must develop a technique for recording the progress of his class. Recording progress is not difficult to learn, if the instructor will develop a technique of transferring grades from the exercises, operations, or jobs to the progress chart. It is one of the fundamental things that an instructor must do in a skillful way.

The progress chart should be posted so that the students will have access to it at all times. This will create a desire for self improvement. It is natural for students to wish to excel, and posting the record publicly tends to inspire them to do so.

Part D

THE LAYOUT SHEET

A good start at the beginning of a school semester is very essential to the success of the instructor of drafting. If the instructor of drafting is prepared when the students arrive, his success is very largely assured. If he is not prepared when the students arrive, he stands a very poor chance of getting prepared afterward. The instructor should bear in mind that whether he is prepared or not, the students will be ready the first day.

Preparedness: The students should be impressed with two evidences of preparedness on the part of the instructor the first day they see the inside of the drafting laboratory. First, a laboratory should be planned and arranged to the last detail, with not one small item out of place. The laboratory should be just the way the instructor expects to keep it throughout the year when his students enter for the first time. Second, there should be evidence that the instructor has in mind a carefully thought out plan for handling classes, issuing supplies, supervising work, etc., and that he knows exactly the motivation techniques to establish.

Layout Sheet: To avoid confusion and unnecessary delay in the starting of a drafting class, the layout sheet, Fig. 4, is suggested. A layout sheet should be prepared for each member of the class, by one of the better methods of reproduction, and placed in their possession the first day of school. This eliminates a hurried explanation on the blackboard by the instructor, or the students going to the bulletin board for layout procedure.

The layout sheet with title block is for an 11 by 17 drawing. The paper size should be 12 by 18, and is trimmed to size after the drawing is completed. The purpose of the wide margin at the left is to leave space for binding. The print of the layout is self explanatory. Although the layout sheet is shown for a 12 by 18 sheet of paper, the size could be reduced one-half and used on a 9 by 12 sheet.

It is good teaching technique not to use the same size layout sheet that the text book recommends. Students should learn to space a drawing early in their drafting experience, and not to depend upon the spacing recommended by the text. By using an "off-size" layout sheet, the student acquires the ability early in his drafting experience to layout any drawing without hesitation.

LAYOUT SHEET

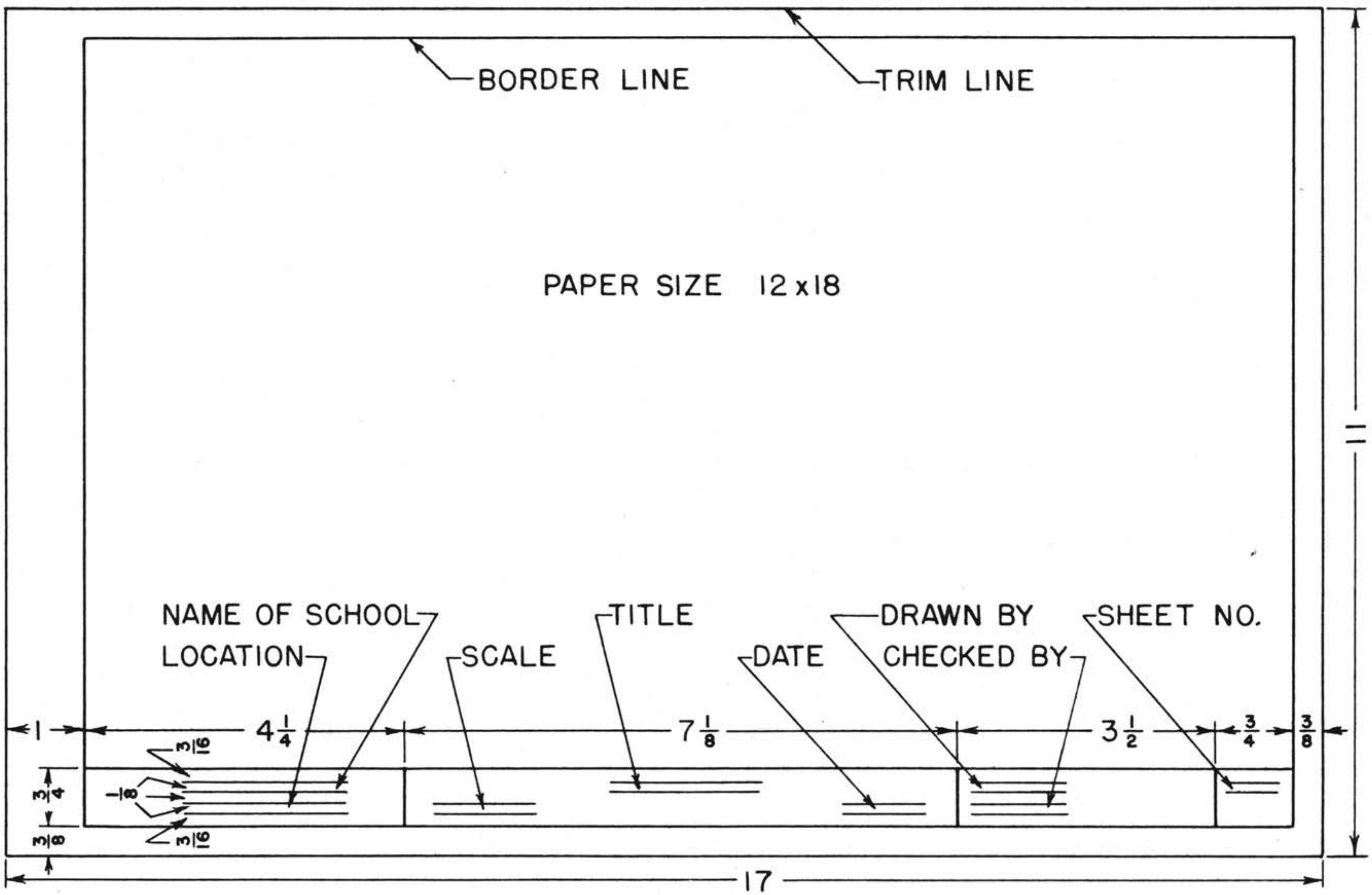


FIG. 4

Part E

BLACKBOARD

The blackboard, Fig. 5 and 6, is the most common and generally accepted medium of visual instruction. Instructors in drafting should develop expert skill in the use of this teaching device. Well executed pictorial drawings, diagrams, and sections will reduce the necessary amount of verbal instruction and thus aid the student in a better understanding of the material. The majority of instructors have failed to appreciate the advantages of blackboard presentation and, therefore, they have made no special effort to become proficient in its use. (19, page 301)

Sketches: There are times when the sketches should be drawn before the period in which they are to be used. This is particularly true in the case of complicated devices and diagrams that would require too much of the class period to complete and could probably create discipline problems. Although the blackboard is an effective device in the hand of the instructor, the student should be requested to use it when he is called upon to explain his understanding of a principle or operation. Every drafting laboratory should have a portable blackboard available.

Colored Chalk: It is well to use colored chalk to accentuate certain parts or materials. The added attractiveness has considerable influence on student interest. Another important feature of blackboard sketching is the use of shading. It will give a drawing depth and will create the illusion of a third dimension.

Use of Blackboard: A good instructor will make use of the

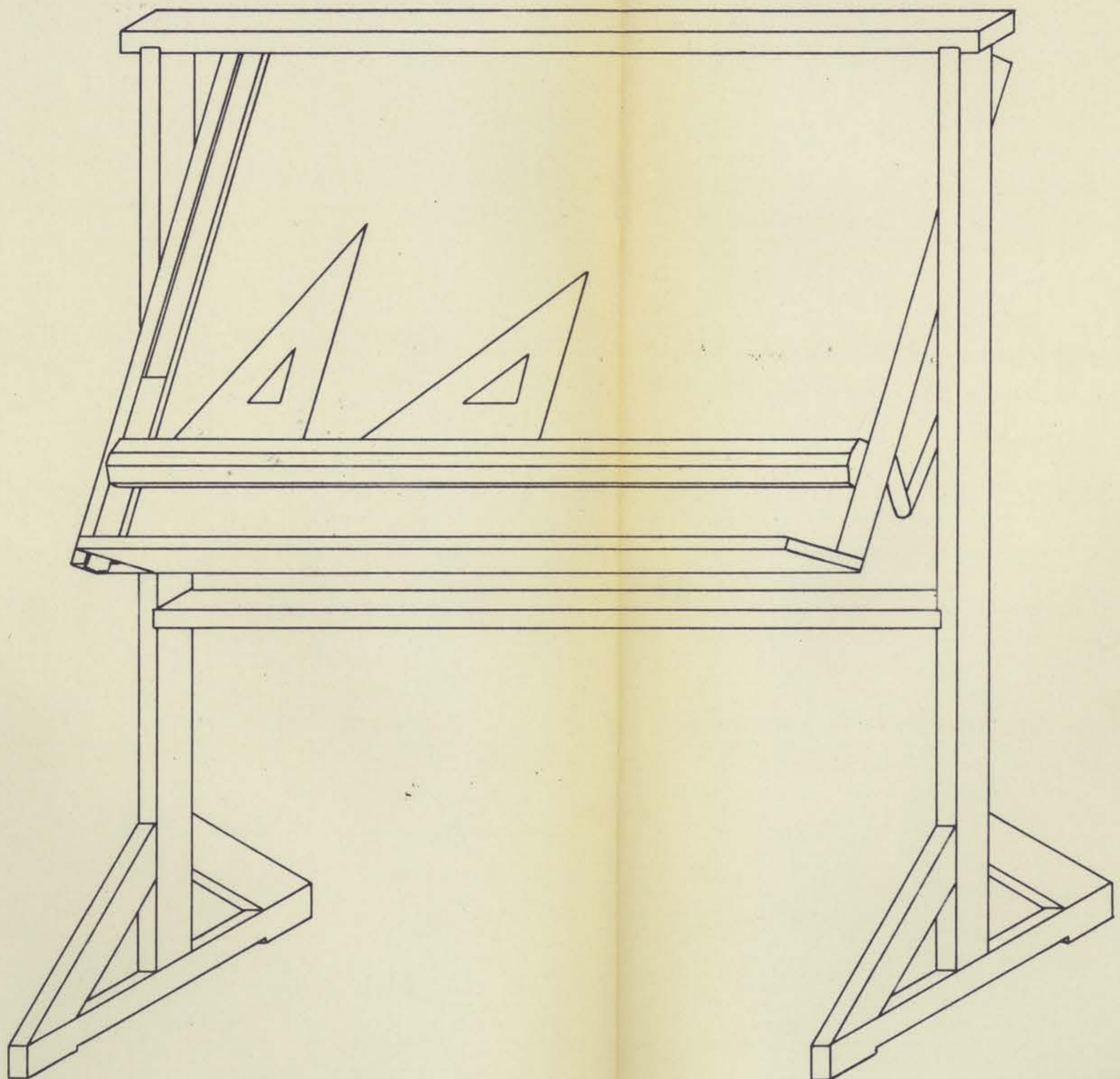
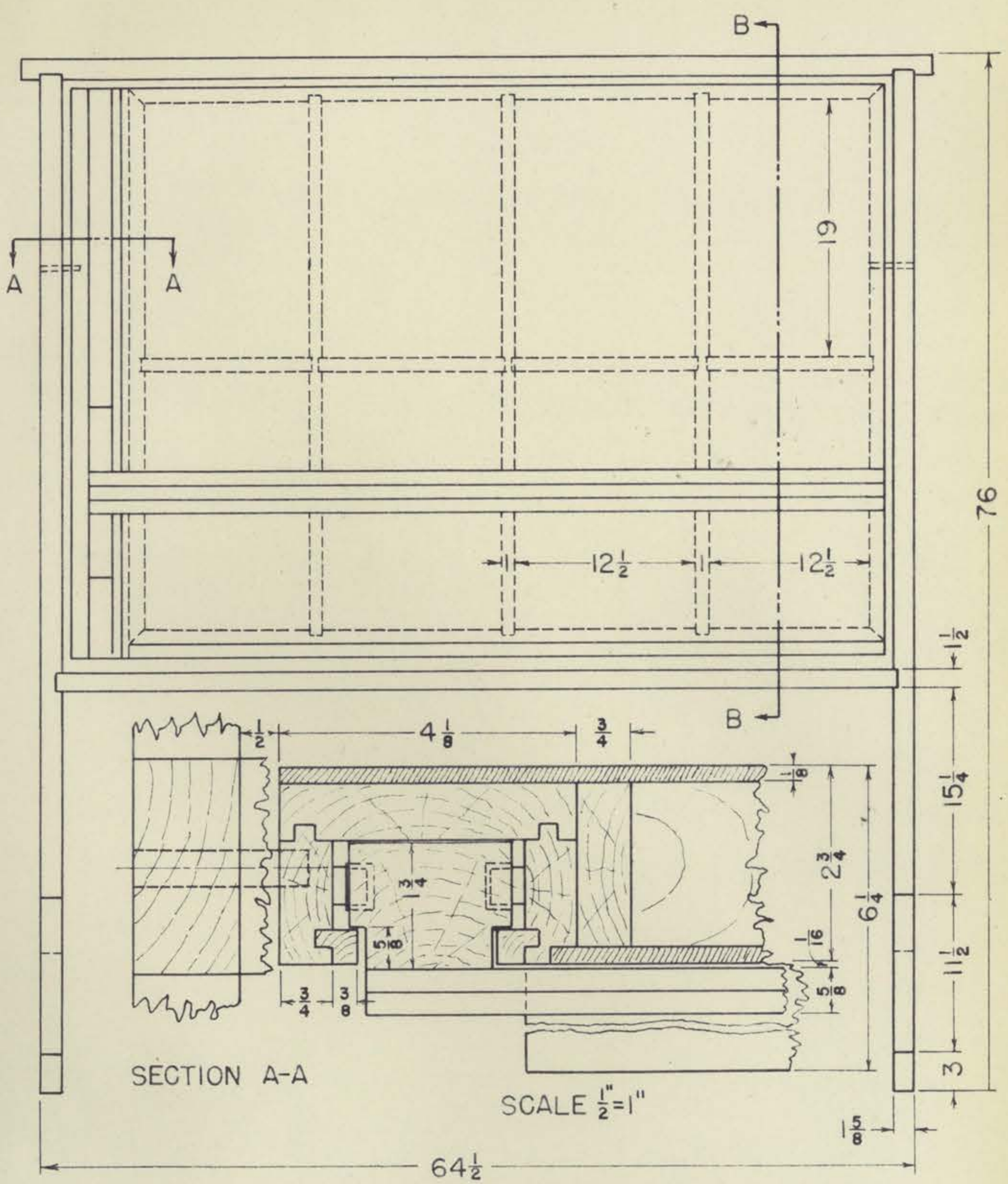


FIG. 5 PORTABLE DRAFTING BLACKBOARD



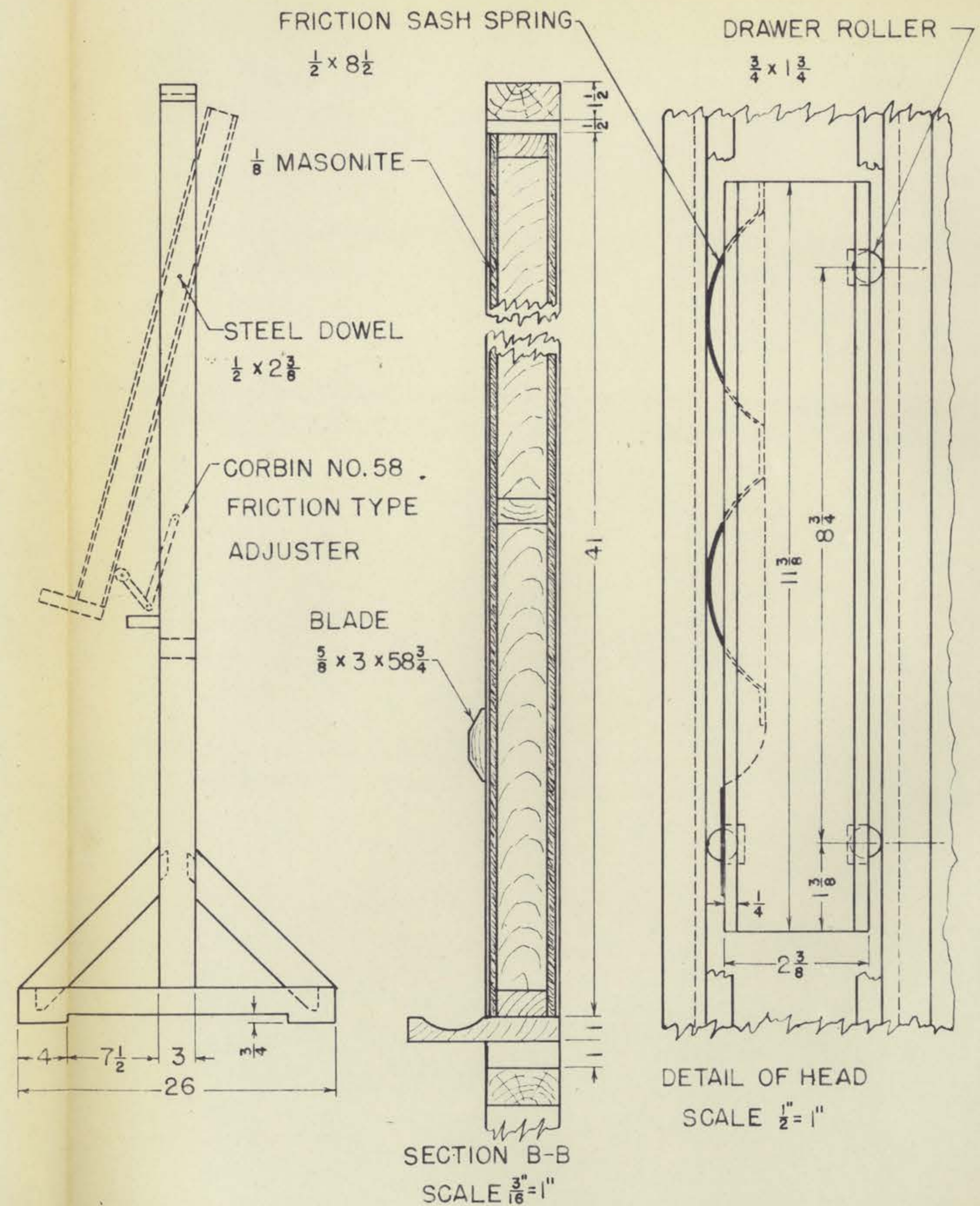


FIG. 6 PORTABLE DRAFTING BLACKBOARD

SCALE 3/32"=1"

blackboard for all new technical words, the names of machine parts and operations, in addition to well drawn sketches. The use of the sense of sight, in addition to the sense of hearing, will increase the learning possibilities of the student.

The instructor should stand in such a postion that he can address the class clearly, and at the same time point out easily on the sketch or drawing, the things he wishes to emphasize. An instructor who faces a blackboard, with his back to the class, forgets that the students cannot see through him, and cannot hear what he is explaining. A pointer is a useful device for teaching from the blackboard. (26, pages 50-51)

Designed and Developed: It is with the above thoughts in mind, that the writer of this thesis designed and developed the blackboard that accompanies this article. As the blackboard is portable, it is desirable that casters be mounted on the base. This will make it possible to move the blackboard around the room for use with special groups. Then, the blackboard can be so placed that the students need not look into the light. Reflected light from the surface of the blackboard should be avoided. Under some conditions, it might be advisable to mount a shaded fluorescent light on the top of the blackboard. This would tend to spotlight the material placed on the blackboard.

The majority of drafting instructors find it very hard to make a presentable drawing, freehand. In the majority of cases, the student is required to make his drawings with the traditional drafting tools, and the freehand sketch of the instructor on the blackboard is of little value. If, on the other hand, the drawing on the blackboard is constructed with the T-square and triangles, the student will learn the correct methods and techniques to use on his drafting board. Likewise, as the drafting board can be tilted to a desirable angle, the blackboard can also be tilted to provide ease for the instructor in drawing, and to avoid an undesirable reflection of light from the writing surface. The blackboard is designed with the thought of using both front and rear of the swinging blackboard surface. While the front may be used, as suggested previously, the back could be used for freehand sketching, tests, solution of problems, etc.

Construction: It is suggested that the portable blackboard be constructed from a hard wood, and extreme care be used in the accurate construction of the track carrying the head of the T-square. The blackboard surface should be of a good grade of presdwood, securely glued and bradded to the frame. The hardware listed is of standard design and can be purchased from the larger hardware stores or supply houses that provide for industrial arts needs.

Naturally, to make such equipment entirely workable, triangles are needed. These may be constructed of 1/4 in. plywood in both 30-60 and 45 degree types. Likewise, a scale may be made from 2 by 2 soft pine, divided and marked to represent all of the scales of a triangular architect's scale. A regular blackboard compass may be purchased, or made, to complete the equipment.

Slating the Surface: A reliable paint supply company should be consulted for material to be brushed on, to form the writing surface. There are many brands on the market and a reliable product maybe easily secured.

Part F

PROJECTION BOX

Probably no course of study in industrial arts has undergone fewer changes during the past 30 years than mechanical drawing. New Text books incorporating the recommendations of the American Standard Association have contributed much toward the standardization of the subject. There is less abstract work in the problems contained in the modern text book. The experience gained from the defence training programs have played an important part in the changed policies of the school drafting laboratory. As a result, many of the instructors are giving more attention to the actual needs of the courses as they apply to the student and his work. Blueprint reading and sketching are now regarded as more important than the mere making of drawings involving technique. Obviously, the majority of the students are not preparing for drafting vocations and the major objective is to teach students to have a working knowledge of drafting.

Teaching Aids: There is one phase, however, in the teaching of drafting which has been overlooked or regarded as not subject to any particular improvement. This is in the methods, or teaching aids, used by the instructor. Grasping the fundamentals of orthographic projection is not easy for all members of a class. Teaching this unit means that the instructor must give individual instruction, blackboard demonstrations, and stress the material in the text book. The student does the best that he can to master these fundamentals. However, there are times when normal, intelligent, and willing beginners find it difficult to understand the printed page, oral instruction, or complex diagrams on the blackboard.

<u>The Projection Box</u>: The box shown in Fig. 7, is made of 3/16 in., water clear, plexiglass. Such plexiglass may be purchased from dealers in craftsman's supplies, companies making plastics, or industrial arts supply houses. To make the box, purchase a piece of plexiglass, 11 by 21 inches, and cut it accurately to the sizes indicated in the drawing. Care must be taken in working out the hinge detail, so that the box may be opened without the hinges binding. The base should be of well seasoned wood, and should be enameled or stained a different color, in order to identify it at a distance. It is possible to plan a projection box of a different shape, to fit the size of the object to be drawn. The corner block may be made of hard wood or three pieces of plexiglass cemented together.

<u>Purpose</u>: The purpose of this box is to show the relationship of the orthographic views of an object, when projected on a flat surface. Many classes in drafting are conducted merely for the purpose of teaching the students to read drawings, and consists chiefly of copying completed drawings, or by completing partially made drawings. The basic principle of orthographic drawing is often neglected to such an extent, that many who have completed such a course, could not draw a simple model unless the instructor supplied specifications for the layout. The majority of students, who have completed a drafting course, have a general knowledge of reading drawings, but it is disappointing to find many who cannot express an original idea graphically in a correct manner. Perhaps the views are not correctly placed or connected or proportioned, as no use has been made of projection lines to save repeated

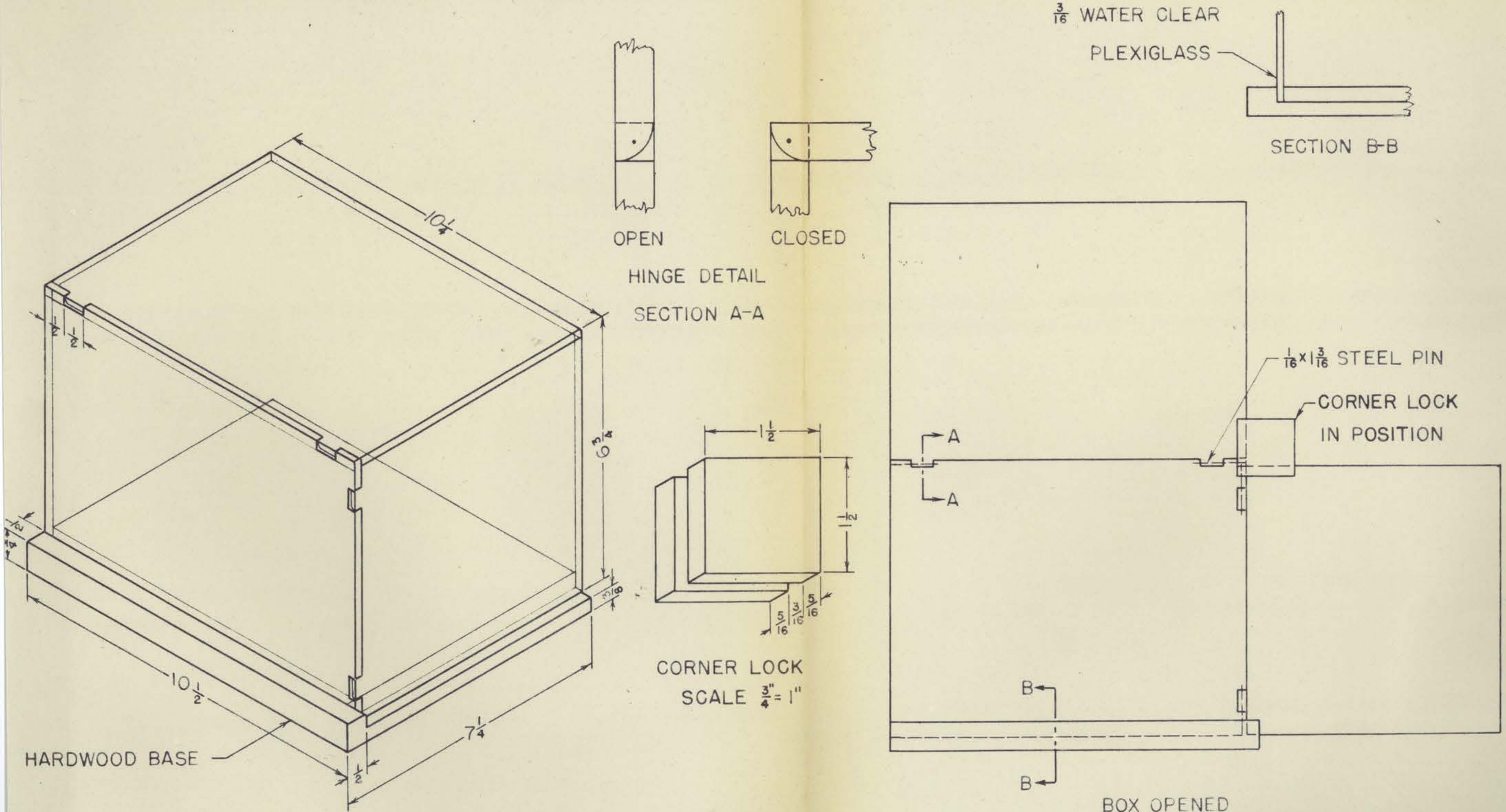


FIG. 7 PROJECTION BOX

SCALE 3/8" = 1"

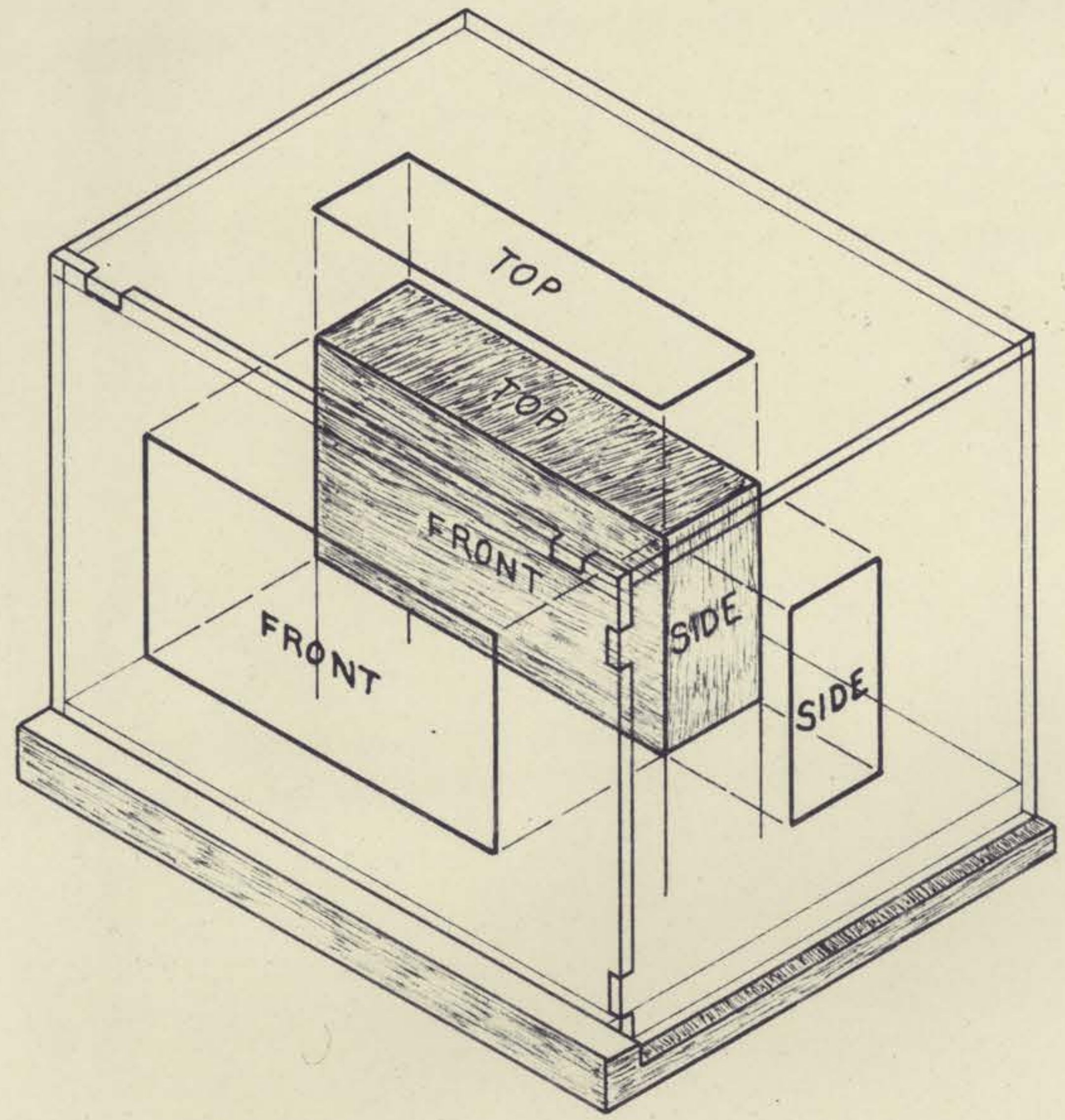
measurements and to prevent errors. (5, pages 81-84)

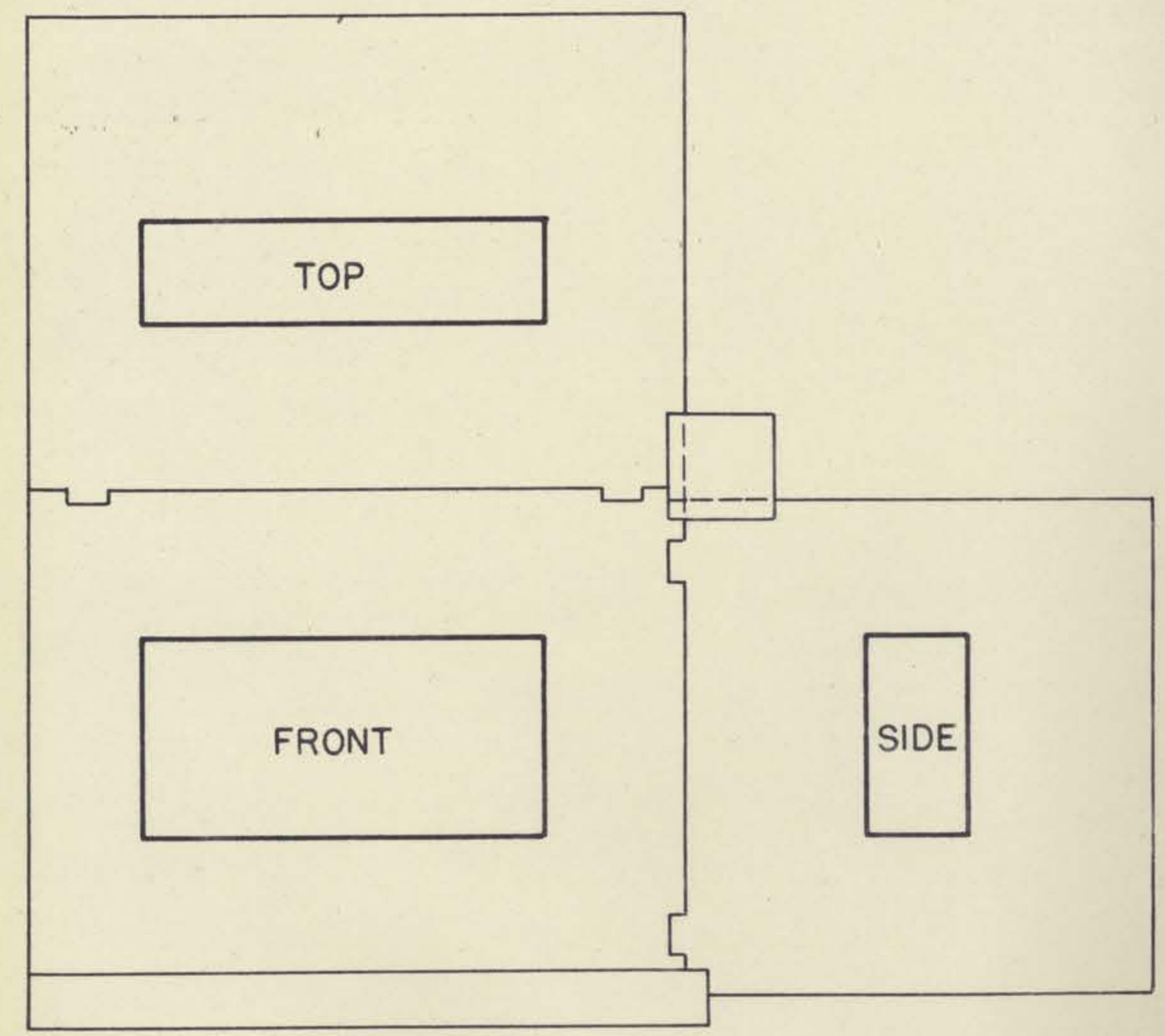
Use of the Projection Box: With the projection box in a closed position, as indicated in Fig. 8, the object to be drawn is placed within the enclosure of the box. To make the object center for the front and side views, it is suggested that supports of fine piano wire be placed on each corner of the base of the object.

It is an accepted rule that the surfaces of an object suspended in space may be projected onto planes to which they are parallel without changing their shape or area. This means that the projection lines are parallel to each other because if they were not, the projected images would be either larger or smaller than the actual surfaces. The process of making an orthographic projection involves the enclosing of the object in a transparent projection box. After having projected its surfaces to the sides of the box, it is opened in such a manner that the corners nearest to the observer are the hinge lines. When the open box lies flat, all the views lie in the same plane. The student will learn that the images are definitely related because the same points are shown in many of the views, except that they are viewed from a different direction. (5, pages 84-86)

It is not always necessary to use all the views which appear when the box is opened. Only those views which together furnish sufficient details for reproduction of the original object are necessary to be shown on the drawing. As a general rule, simple objects require the use of three views, and in many cases less than three.

After observing the demonstration of the projection box, the students should be permitted to place their models in the projection box, and work out their problems. To complete the lesson on orthographic





BOX OPENED

FIG. 8 PROJECTION BOX

projection, the student will draw the necessary views of the assigned object.

Part G

GLASS-TOP DRAFTING BOARD

The glass-top drafting board illustrated in Fig. 9, and described herewith may be made quite easily in the school shop. Its construction does not involve great expense. It is made with a glass top size of 14 by 18 inches to accomodate the standard layout sheet, illustrated in Fig. 4. Around this glass, a frame 3 inches wide is constructed. The total overall size of the top is 20 by 24 inches, which is the size of the standard school drafting board. The top is hinged for the following purposes; (1) to facilitate emergency ventilation, (2) to adjust the tilted drawing surface, and (3) easy access to the bulbs. The glass top is made of two pieces of double strength glass, to give additional strength. It is desirable to place a piece of tracing paper or cloth between the two pieces of glass, so as to diffuse the light. (32, page 31)

The reflector is of sheet aluminum. In order to insure ventilation, openings are made in the two sides and the back. For illumination, eight 20 watt tubular bulbs may be used. They are arranged in two sets, each with a separate switch. This separation of the circuits allow for choice of intensities. The material used in the construction of this drafting board should be of a hard wood, and finished to harmonize with the drafting equipment.

Use of Glass-top Drafting Board: The use to which the drafting

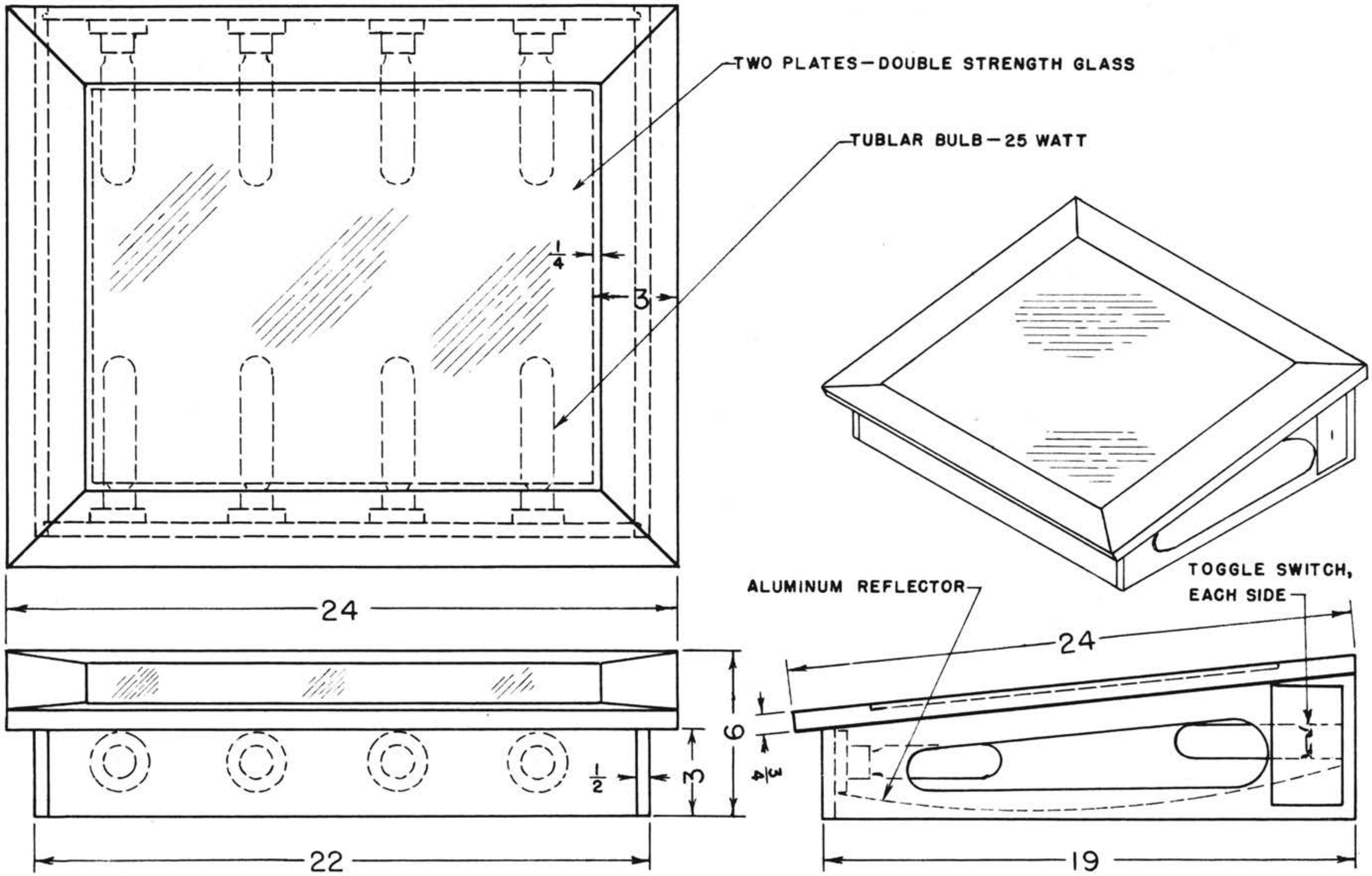


FIG. 9 GLASS TOP DRAFTING BOARD SCALE $\frac{3''}{16} = 1''$

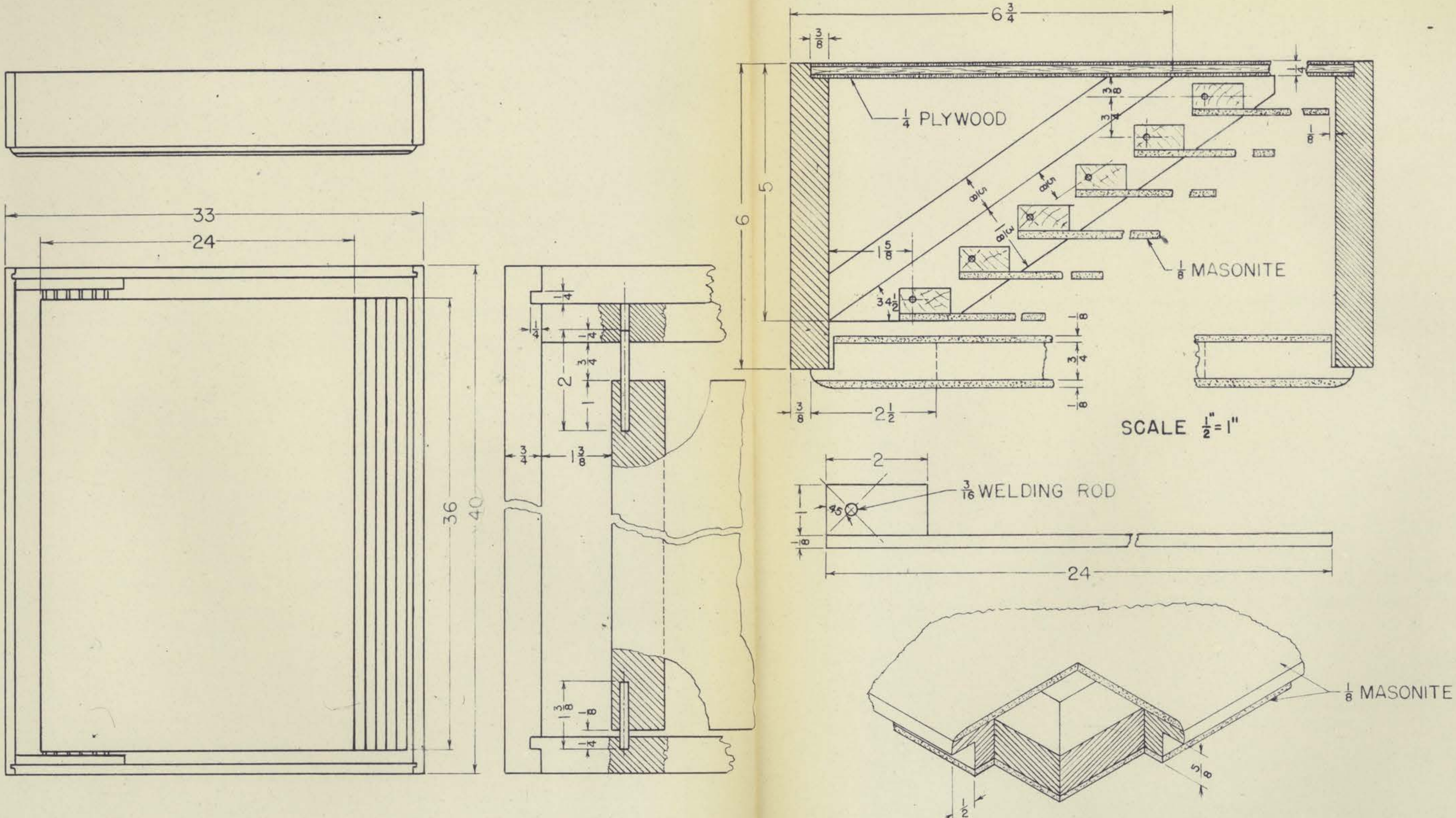
board can be extended is limited only by the imagination of the instructor and students who made use of this device. For the instructor, the illuminated board may be used, to prepare copy for any of the duplication and reproduction processes, check drafting problems from a master copy, comparison of the individual student problem with that of the rest of the class, and to illustrate correct weight of lines. For the student, the illuminated board may be used to prepare copy for student publication, to check their drawings with each other for possible errors, and ease of checking for completeness of drawing.

Part H

CHART CABINET

Charts are used to draw the attention of the class to important facts or ideas. Charts are visual representations of facts, situations, or objects for making comparisons, for summarizing, or for showing quantities and developments. Excellent charts can be made showing such things as functions of working parts, the care and servicing of equipment, pictorial symbols, exploded drawings, and details of construction. Manufacturers have placed at the disposal of the drafting instructor, many charts that are indispensable in the teaching of drafting. To choose the type of chart that will best present the idea, the instructor must know exactly what the chart is to show and be familiar with the different possibilities of display.

Storage of Charts: The securing of charts, rolling them up, and filing away in a cabinet serves neither the instructor or the student. A suitable storage and display cabinet, Fig. 10, is needed to secure



HINGE DETAIL

DOOR DETAIL

FIG. 10 CHART CABINET SCALE 1/8" = 1"

the greatest benefit from the chart. With this thought in mind, the chart cabinet was designed. The construction is quite simple and would not be difficult to construct in the school shop. The depth of the cabinet could be increased to make available an increased number of swinging panels. It is to be noted, that the hinge on each panel is so constructed that the panel can be removed by pushing the panel upward until the lower dowel clears the supporting member and then pulling the panel outward from the bottom. Special attention is called to the construction of the door. This type of door will not warp, and is light in weight. Even the inside of the door could be used for chart display, as well as each side of the swinging panels. Scotch cellulose or drafting tape serves a very useful purpose of securing the charts to the swinging panels. With the door closed, except when the charts are in use, the charts will remain clean and in an usable condition for many years.

Part I

INDUSTRIAL DRAFTING CHECK LIST

Instructors are very prone to instruct their classes in the same manner year after year. Certain devices have been found to be good teaching technique. These have been kept and used continuously which has produced a deadening effect on the instructor's initiative. There are many other devices which, if used, would produce more pleasant pupil experiences than the traditional methods used. The course of study cannot be changed to a great extent, but the procedures can be varied.

<u>Corrections</u>: It is traditional for a drafting instructor to write corrections on the student's drawing, during the process of grading. This tends to detract from the appearance of the drawing and creates within the student the desire not to show his drawings to others. However, if the industrial drafting check list, Fig. 11, is prepared in advance, passed out to the students with a few words of explanation, and is conscientiously used by the instructor, the students will appreciate the corrections made on the drafting problem.

<u>Check Mark</u>: Errors are noted on the students drawing by a check mark with a number and letter. For example; \2D shows that the indicated lines did not meet at a definite point and a neat joint did not result. This check mark should be made lightly, with a soft pencil. This will allow the student to check and correct his errors, erase the check marks, and then not be ashamed to show his drawing.

<u>Conclusion</u>: The expanding program of drafting in the public schools have developed a greater need for more elastic teaching aids. It is wise to make the teaching aids flexible enough to cover the field of drafting. While teaching drafting, the instructor is frequently confronted with the problems that become time consuming in his efforts to assure full comprehension on the part of the student. Proper teaching aids at the right time are often tremendous timesavers and produce a more thorough and lasting impression.

Many of the best teaching aids used in the laboratory are made by the instructor or under his direction. There are several advantages in making them. The teacher may prepare just what he wishes to show in an aid and omit all unimportant or undesirable features. These

DRAFTING CHECK LIST

1. VIEWS
   - A. Selection--Have proper views been selected which most clearly picture the object?
   - B. Placement--Are the views placed in proper relationship and located so that the sheet is balanced?
   - C. Scale--Is the drawing too large or too small for the sheet?
   - D. Completeness--Are there too many or not enough lines?

2. LINES
   - A. Type--Has the right kind of lines been used in each part of the drawing?
   - B. Weight--Are the lines of proper width and density?
   - C. Uniformity--Are all lines of each type the same throughout the drawing?
   - D. Junction--Do the lines meet at a definite point so that a neat joint results?
   - E. Erasure--Are the erasures adequate and neat?

3. DIMENSIONING
   - A. Placement--Are dimensions conventionally located to give good balance and readability?
   - B. Completeness--Have any dimensions been omitted or duplicated?
   - C. Accuracy--Do the dimensions conform to those of the problem?

4. ARROW HEADS
   - A. Size--Are the arrow heads the proper size for good appearance?
   - B. Weight--Are the lines of the arrow heads of correct width and density?
   - C. Shape--Are they properly proportioned and conventionally formed?
   - D. Uniformity--Are the arrow heads the same throughout the drawing?

5. LETTERING
   - A. Size--Are the letters of appropriate size?
   - B. Weight--Are the lines of the letters of correct width and density?
   - C. Shape--Are they properly proportioned and conventionally formed?
   - D. Spacing--Is the proper spacing used between letters and words?
   - E. Guides--Have guide lines been used and properly spaced?

6. SPECIFICATION AND NOTES
   - A. Placement--Are the specifications and notes conventionally located, easily read, and well balanced on the sheet?
   - B. Completeness--Are there sufficient specifications and notes to give necessary information?
   - C. Accuracy--Do specifications and notes give correct information?

7. CLEANLINESS--Is the drawing free from dirt and smudges?

Fig. 11

can be made to the size most desirable for laboratory use, and with a minimum of expense. It is much easier to teach drafting when the instructor has at his command, all the teaching aids involved in a course. This is a more positive approach to teaching.

The drafting teaching aids discussed in this chapter are a few of the many items that may be designed and constructed for use in the drafting laboratory. If the instructor has the time and material, the development of drafting teaching aids would modernize the instruction in the drafting laboratory.

CHAPTER 4

LABORATORY AND EQUIPMENT AIDS

The responsibility which rests on an instructor assigned the task of planning for a drafting laboratory of a school, is an important and challenging one, and the task demands considerable thought and insight. Errors in room planning and equipment purchases are costly, in terms of money. Wrong planning and wrong equipment selections may obviate the very purposes being sought through the drafting laboratory experiences. The problem should, therefore, be approached with a thorough understanding of the general educational philosophy and of the objectives of drafting as a guide.

The importance of the equipment and its function in carrying out the aims and purposes in the drafting laboratory is a factor conditioning the teaching process of drafting. This is a matter not given due recognization by too many instructors in the field of drafting. It is only too evident to the experienced instructor that the behavior of the students while they are in the drafting laboratory may be greatly influenced by the many opportunities it affords them in giving definiteness to learning in all the instructional areas. Indeed, the success of the instructor may hinge upon the factor of laboratory layout, equipment, understanding of mechanical principles, aids, and devices of the modern drafting curriculum.

Part A

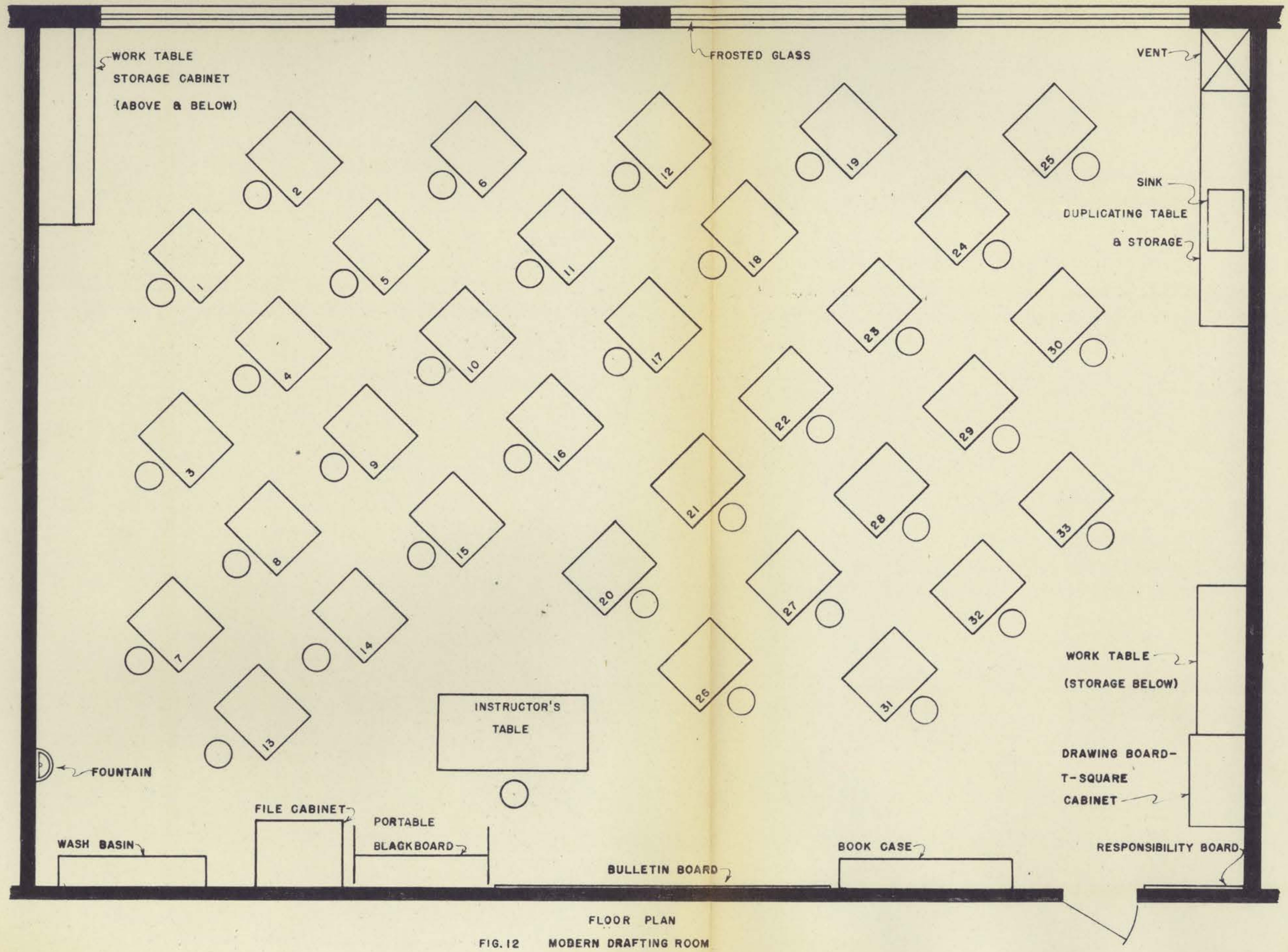
THE DRAFTING ROOM

A drafting room in a unit industrial arts program is a room devoted entirely to the exploratory and training of students for the various fields of drafting. The drafting room should have facilities for training the students, whereby they will gain a wholesome experience with objects, and make drafting the record of those experiences which include use of materials, processes, and many other factors.

The major problem in laying out a new drafting department, or in reorganizing an old one, especially in the small school, is to get the most usable space, the most suitable equipment, and the very best program possible with the means available. To this end, the department should be carefully planned in detail before construction begins and before equipment is constructed or purchased. In any event, the drafting room should be constructed, equipped, and arranged so as to insure: (1) instructional convenience, (2) safe and economical operation, (3) ease of administration, and (4) maximum educational values to the stuent.

<u>The Drafting Room Layout</u>: The proposed layout, Fig. 12, shown and described in this article is a planned layout, embodying some of the improvements to be desired in a modern industrial arts drafting room. The proposed plan calls for a room approximately 34 feet 6 inches by 49 feet. With a floor area of 1691 square feet and drafting tables provided for 33 students, this makes approximately 51 square feet of floor area space per student. Newkirk and Johnson, in their book on the <u>Industrial Arts Program</u>, suggested 40 square feet of floor area space per student in a high school drafting room and slightly over 64 square feet per student in junior high.

The ratio of the width of the drafting room to the length is approximately one to one and one half. This allows for a sufficient



FLOOR PLAN

FIG. 12 MODERN DRAFTING ROOM

amount of window space along the front of the drafting room.

Drafting Room Arrangement: The writer of this thesis has taught in a number of different rooms, attended drafting classes in others, and visited in many others. The idea for the proposed drafting room was gained from visiting the drafting room of Mr. S. S. Orman, Central High School, Tulsa, Oklahoma. When the writer stepped into the drafting room, a feeling of freedom and a complete breakdown of the traditional arrangement was noticed. The proposed plan is not an exact copy of Mr. Orman's drafting room, rather a plan that could be adapted to any room of the same ratio, varying the number of drafting tables with the floor area.

The arrangement of the room shown in the accompanying drawing, alleviates some of the factors usually found in the drab, formal drafting room. In the first place, the novelty of any change made in the traditional drafting room creates a desirable change in attitude. The arrangement of the drafting tables provides a distributed light, balanced as much as possible under the circumstances, for the greatest number of students.

The room looks very spacious and free from encumbrances. The students can move around very freely without disturbances. The instructor can see the students, at work, at a glance and can move around from table to table very quickly and unobtrusively. Generally, the change will build up a tremendous psychological lift. Since the isolation and tightness of the formal drafting room no longer exists, the students feel at home and behave as they naturally would.

The arrangement of the portable blackboard near the instructor's table, makes possible the moving of it to any free area. If moved to a position directly back of the instructor's table, all students can turn on their drafting stools to view the material being placed on the blackboard. Being turned sidewise from their tables, the students are not confronted with the desire to continue work on a drawing while listening to their instructor.

The furniture necessary in a drafting room is located around the sidewalls of the room, to provide for the greatest convenience of students and instructor. As the student enters the room, he can stop at the responsibility board, and perhaps even pick up a book from the book case on the way to his drafting table. The duplicating table is equipped with a vent for Ozalid developing, sufficient room for a small reproduction printer, washing space for blueprints, and suitable storage underneath.

The wash basin and fountain, necessary equipment in a drafting room, are located where they will be least noticed when entering the room, yet readily available to the occupants of the room.

Illumination: The desirable condition for the drafting room is natural illumination, with an abundance of evenly diffused light with a minimum of shadows. The windows being along one side of the room, located from 36 to 40 inches above floor level to the ceiling height, being of frosted glass, allows for a maximum of natural light from one side. According to Newkirk and Johnson, in their book on the Industrial Arts Program, the artificial illumination for a drafting room should provide for at least thirty foot-candles on the drafting tables. To gain this illumination, 3 rows of louvered fluorescents with four 40 watt bulbs, are equally spaced across the width of the room, the rows running the long way of the room. Each row of fluorescents should be controlled by a separate switch near the entrance of the room. This allows the use of independent rows, to bring the natural light up to the requirement for individual tables. In Mr. Orman's drafting room, with a lighting system described as above, it is impossible to find a shadow in any part of the room and during any part of the school day.

Type of Drafting Tables: Two different types of drafting tables are described in chapter four of this thesis. Either may easily be constructed in the industrial arts shop, and will meet the requirements of a modern drafting room. It is considered a good practice to have the tables of sufficient height that the student can stand up. Then, provide a stool of the correct height to seat the student comfortably at the table.

Storage Space: A careful study of the floor plan will indicate storage space provided for continuous use of the drafting room during the school day. Attention is called to the file cabinet, near the instructor's table, for the filing of instructional material, drafting supplies, and completed drawings turned in by the students. Individual storage could easily be taken care of by use of the cabinet space under the two work tables. The book case is readily accessable to all users of the room.

Color in the Drafting Room: The interior color treatment of a drafting room must be approached from two angles. Of primary importance is the creation of an environment that is at once pleasant and stimulating. Added to this is the use of finishes that possess sufficient resistance to withstand the rigors of repeated washing and cleaning. Modern science has established the fact that color is a specific teaching aid. By employing color as outlined in the principles of color dynamics, drafting rooms have increased efficiency and production because color possesses inherent power. The new technological develcoments in maintenance finishes plus the knowledge of scientific color application now makes it possible for the average drafting room to have a decorative pattern that is both beautiful and durable. No longer should measures of economy and durability be the barrier to making the drafting laboratory as attractive as other rooms of the modern school. By careful choice of finishes and proper selection of colors, the atmosphere of the drafting room can be transformed into a direct teaching aid.

Part B

PORTABLE DRAWING BOARD

With the increase in enrollment, the drafting laboratory maybe crowded to overflowing during the entire school day. The beginning drafting classes are usually, in this case, assigned to another room. In all probability the room will be well supplied with flat top tables, and perhaps even stools, yet these tables are indirect contravention to the basic philosophy in underlying drafting laboratory situations.

Drawing Board: With the above thought in mind, the portable drawing board, Fig. 13, is suggested. As the name implies, it is a standard drawing board made usable in any room. To the back of the drafting board is attached the two supports to form the base. Aside from forming the base, they provide a slanting top much like the standard drafting table. The supports are held in a vertical position by a

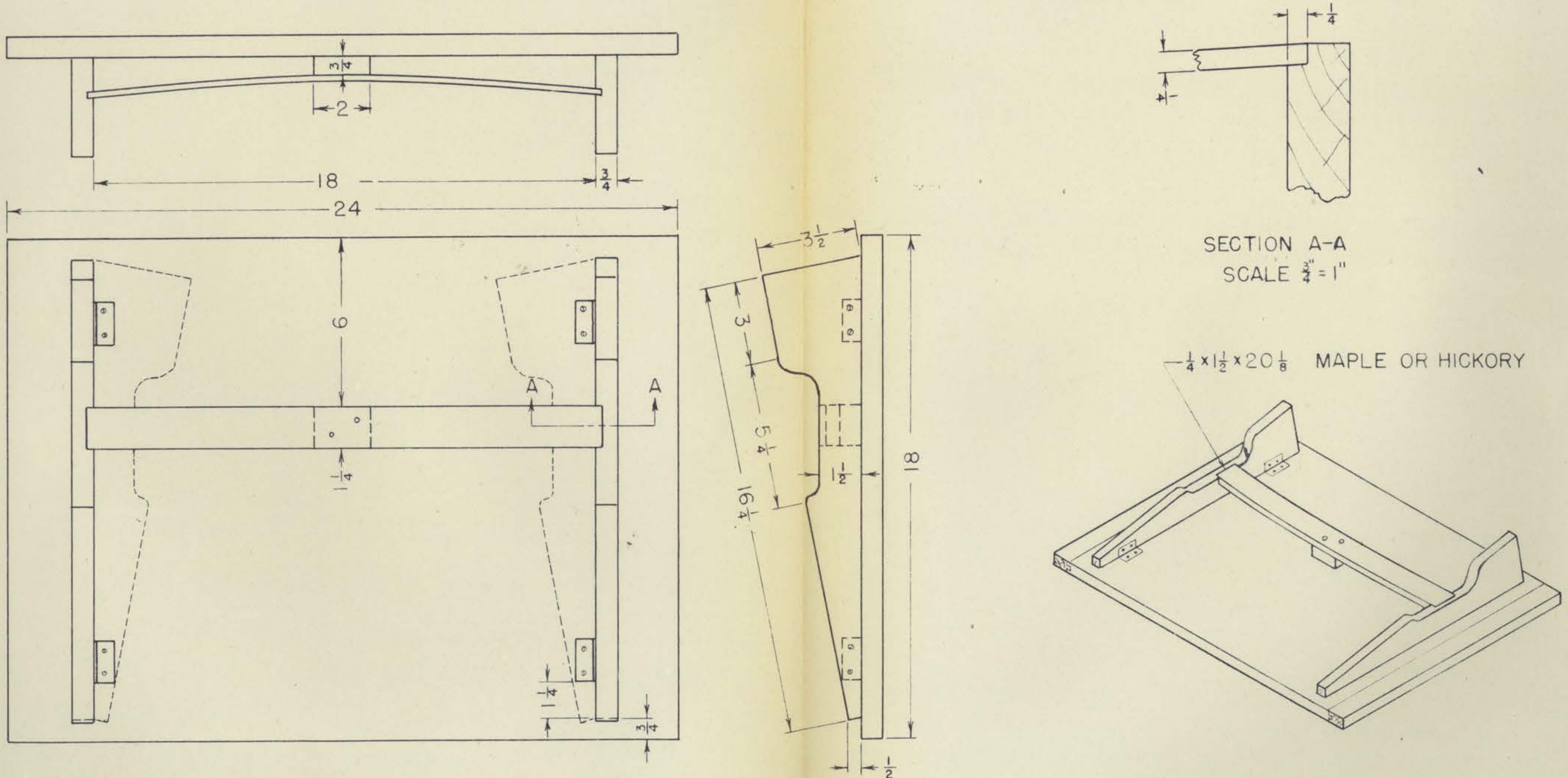


FIG. 13 PORTABLE DRAWING BOARD SCALE $\frac{1}{4}$" = 1"

spring formed from 1/4 by 1-1/2 by 20-1/8 piece of hard wood. When the boards are not in use, they may be easily collapsed, the T-square placed under the folding supports, with drafting tools along side, and stored end-wise in a drafting board cabinet. The cost is very minimum to make this addition, while the satisfaction to the student and instructor is one of indemnification.

Part C

DRAFTING TABLES

The drafting table is the work station of the student in the draft-laboratory. This is the place or area where he will spend the greater part of the period and perform the greater part of his work. With a suitable table upon which to execute the many operations required in a drafting room, the student will feel at ease.

Frame Drafting Table: The drafting table shown in Fig. 14, is one of the conventional type found in the drafting laboratory. It could easily be constructed in the cabinet shop, on a production basis. The rigidity of this table is due to its frame construction and brace of 1-1/4 in. pipe, which forms the foot rest. It will be observed that the top is adjustable for choice of slope. The total height of the table is suitable for standing while drawing, or the student may be seated on a stool 30 in. high. This is suitable to the average learner enrolled in the drafting course.

Metal Drafting Table: The drafting table described in Fig. 15, can be constructed at a low cost in any school that is supplied with welding equipment. It is simple to design, has an all-metal base, and

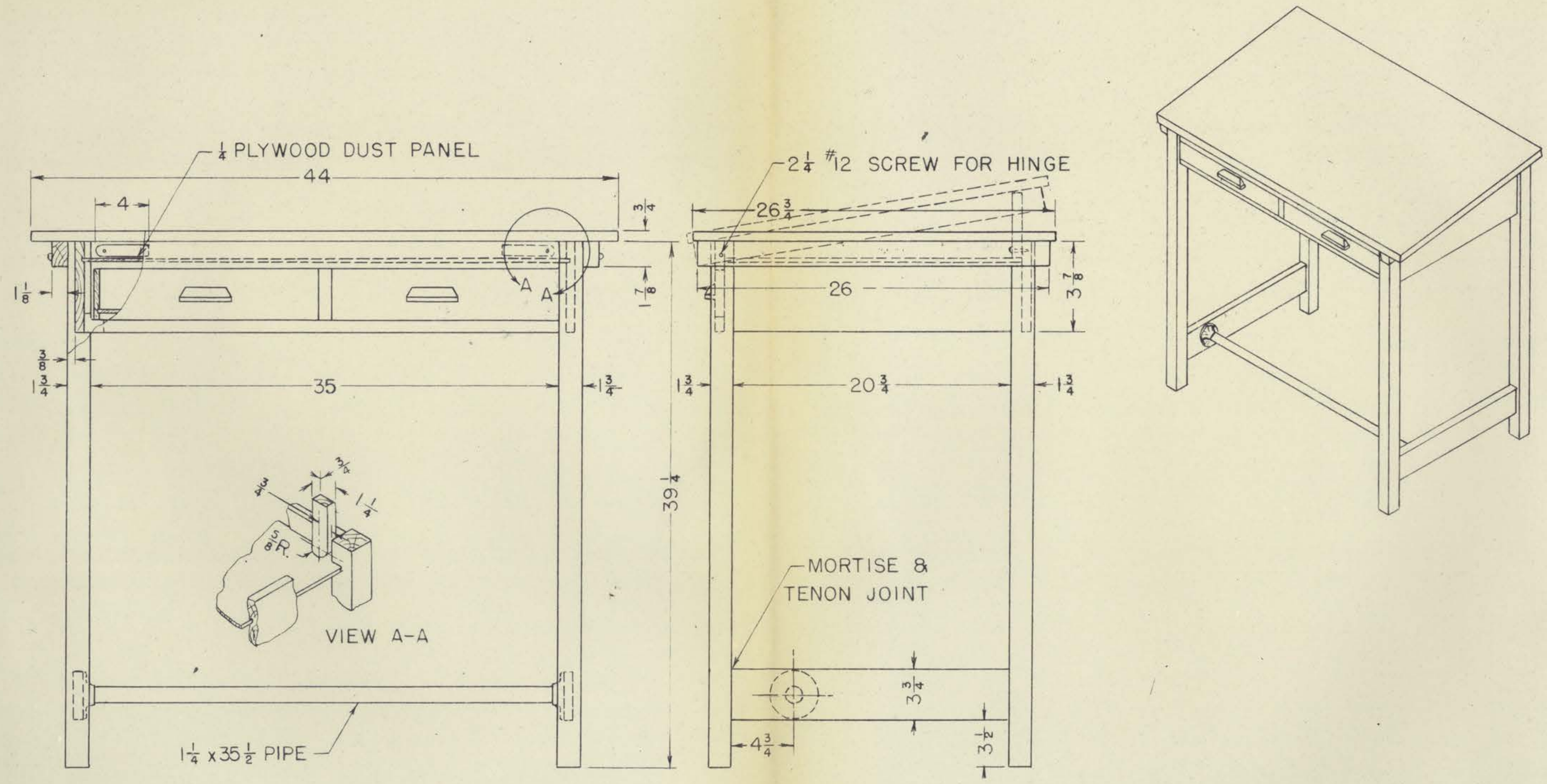


FIG. 14 DRAWING TABLE SCALE 1/8" = 1"

ME—COLD DRAWN
MLESS MECHANICAL
BING

E-D—CAP SCREW
P PT. 1/4—20NC-3

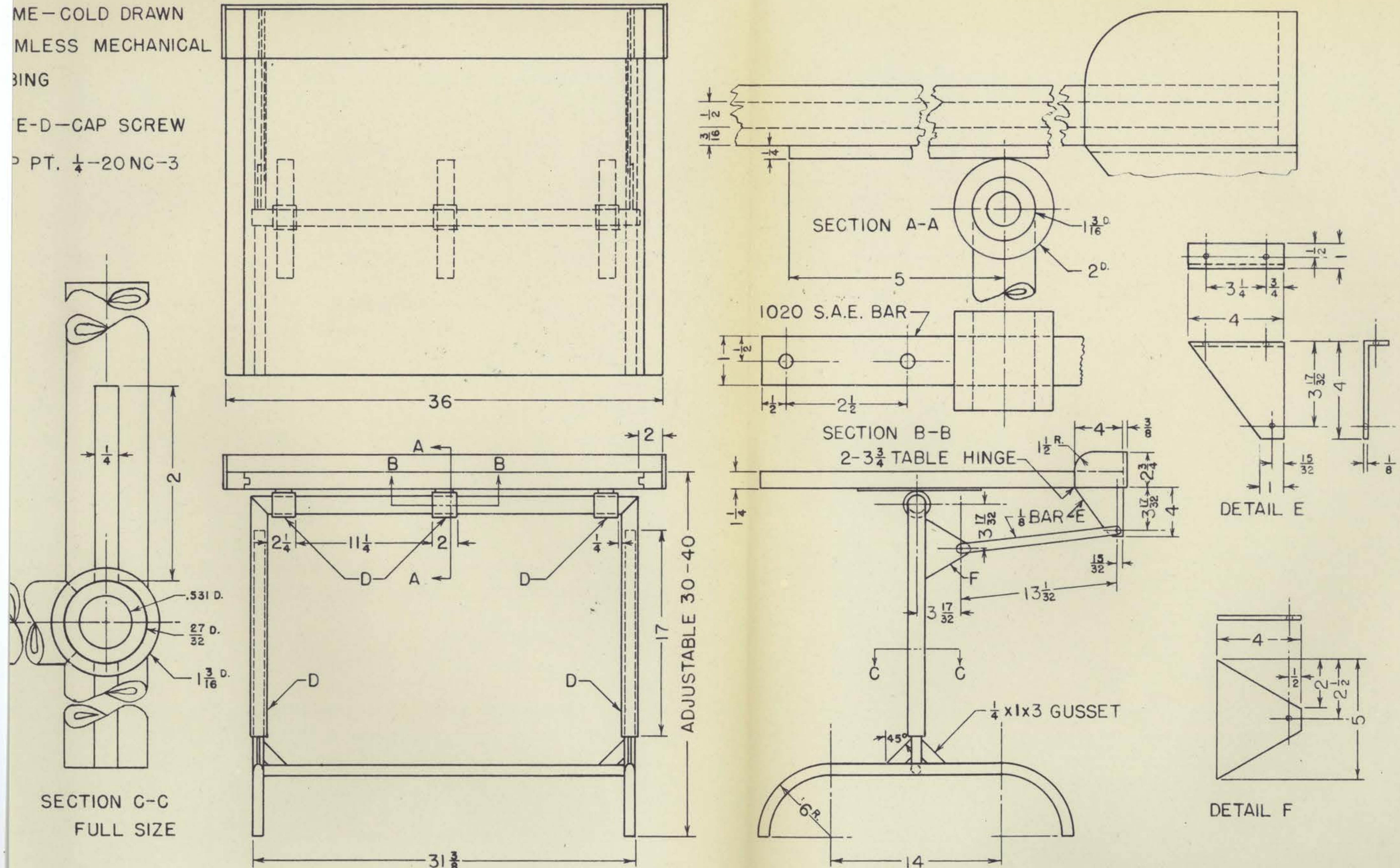


FIG. 15 TILT-TOP DRAFTING TABLE SCALE 1/8" = 1"

is rigid as well as durable. With the use of jigs, it can be rapidly assembled.

The table height is adjustable, as well as the slope of the top. With this adjustment, the table can be made suitable to the average height of the students enrolled in the drafting course. The top is constructed of wood, and of sufficient size to accomodate all types of public school drafting.

Instructors of drafting are faced with the problem of efficient arrangement of necessary equipment on the drafting table. The hinged portion on the front of the top is designed to hold that part in a level position, regardless of what position the table top is set. The additional shelf, added to the front of the top, holds the instrument case, irregular curves, triangles, ink bottle, etc. This arrangement will keep the instruments from sliding and the ink bottle from slipping off the table top. The additional shelf is so arranged that it will not interfere with the movement of the board or T-square. The shelf allows free use of the entire table top for drafting.

Part D

DRAFTING STOOL

One of the essential pieces of equipment in the drafting laboratory is the stool, Fig. 16. To purchase the required number of stools, for the drafting laboratory, would involve a considerable amount of money. A project of making the drafting stools would be worth while economically, and of high educational value to the student. The construction of the stools could be so organized, as a project, for the semester. The operations introduced to the welding student are those

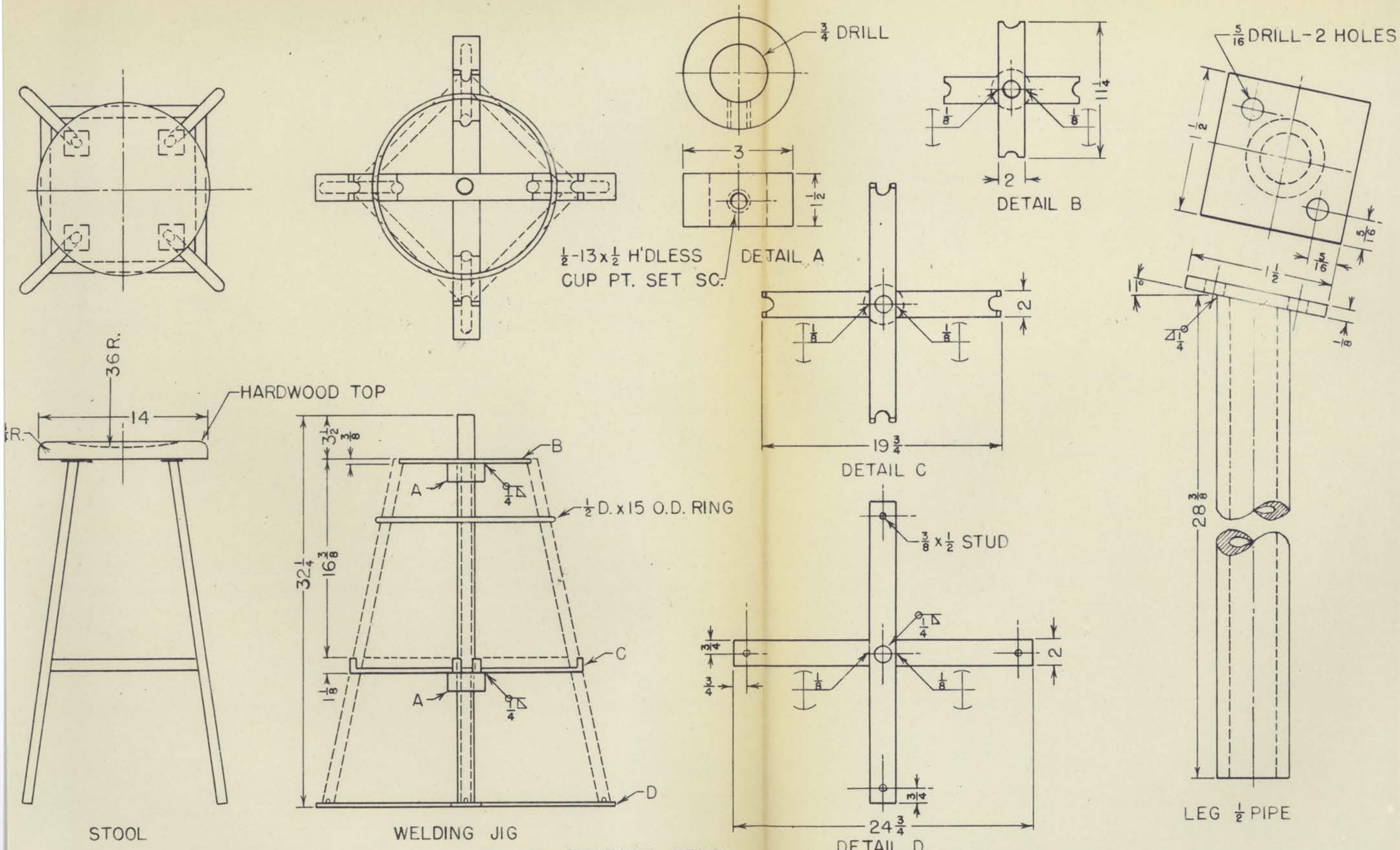


FIG. 16 DRAFTING STOOL
SCALE ⅛" = 1"

that every beginner should learn.

Jigs: Modern methods demand modern production facilities. Therefore, to expedite the assembly of the stools, and to insure the proper alignment of each part, a jig was constructed for this work. The jig is inexpensive and the time element involved in its construction would be compensated for by the speed in the production of the stools. The jig is so constructed, that the height of the stool can be varied to suit the individual needs. This is made possible by the top and middle crossarms of the jig being movable on the central support.

Construction: The operations involved in the making of the stool are as follows:

1. Cut the legs to length.
2. Place the legs in position, and slip the 1/2 in. ring down over them. This serves as a clamp to hold the legs in position.
3. Cut the four leg braces to length, and slip them into position resting on the middle crossarm, of the jig.
4. Tack weld the four leg braces to the legs.
5. Remove the partially welded stool, from the jig, and weld the 1-1/2 by 1-1/2 plate to the top of the leg. This can be accomplished, by turning the stool upside down on a flat surface.
6. The top being of hard wood and previously turned, should next be fastened to the plates with 5/16 by 1 in. lag screws.
7. With the top fastened in position, the braces should be completely welded to the legs. By fastening the top to the legs, before completion of welding, the frame work of the stool will not distort from the correct shape.

8. The rough spots should be smoothed and all scale and dirt removed, preparatory to painting.
9. The color of the stool should be one that will harmonize with the color scheme of the drafting laboratory.

The wood seat is sufficiently strong to support any normal load that might be applied. Having the stool welded, instead of bolted, eliminates the possibility of any moving parts that might get loose and thus insures safety. This, also, removes any occurrence of squeaks and other undesirable noises at the same time. The addition of crutch tips, to each leg, will make the stool noiseless and create little wear on the floor.

Part E

DRAWING BOARD AND T-SQUARE STORAGE CABINET

The storage of drawing boards and T-squares, as well as the tools, is a problem that confronts many instructors in the drafting laboratory. It is wise economy to have the drafting tables cleared of all drawing equipment at the close of the day, for the following reasons; (1) this permits the cleaning of the room for the next day's classes, and (2) the instructor, who is responsible for the drawing equipment, can be reasonably assured that all of the stored equipment is in readiness to start the first class in the morning.

The Cabinet: The storage cabinet, Fig. 17, is designed to hold the drawing boards, T-squares, and drawing tools. The problem of designing involves; (1) sufficient space to care for the total number of drafting boards, (2) safety for the material being stored, (3)

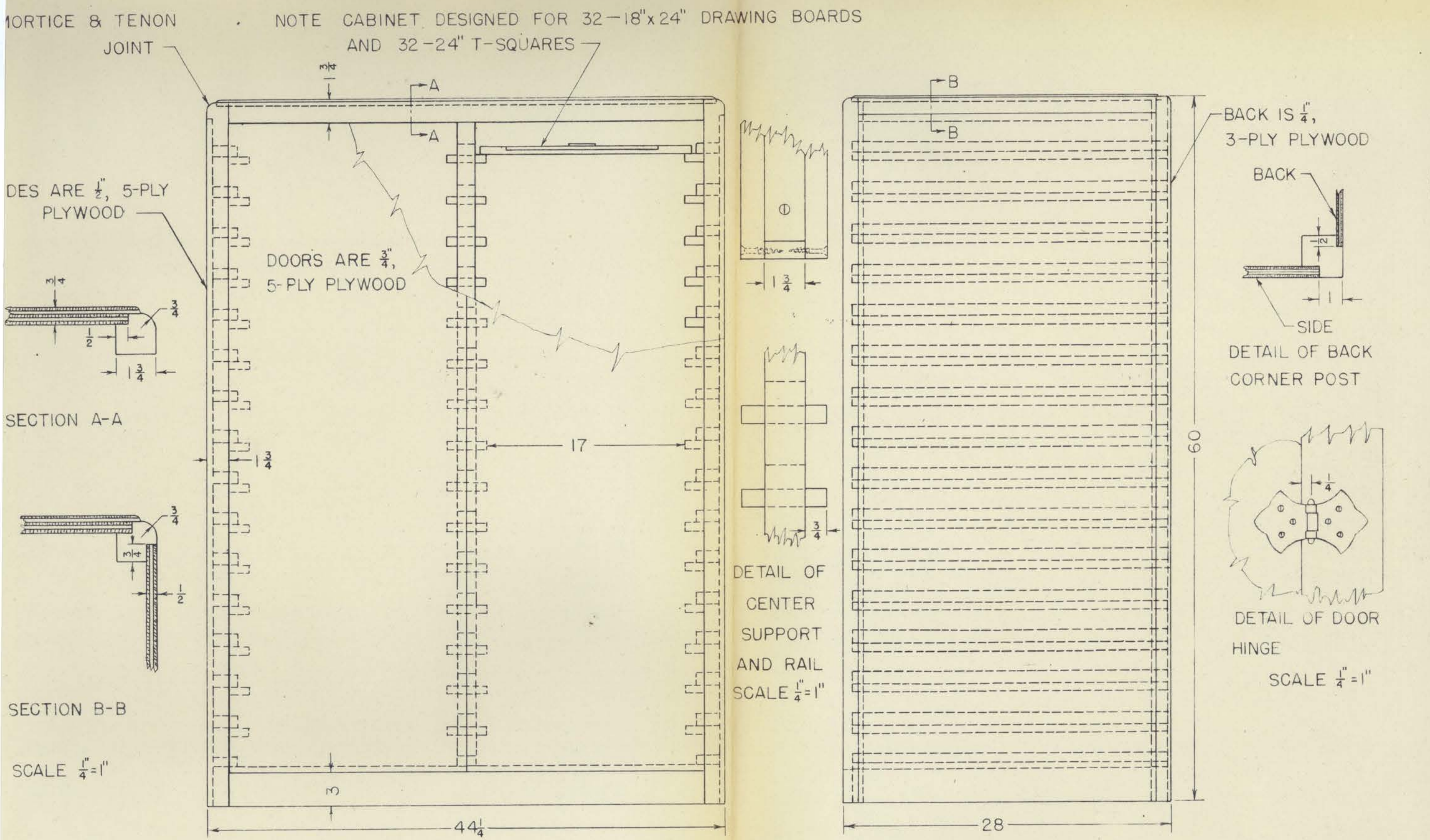


FIG. 17 DRAWING BOARD AND T-SQUARE STORAGE CABINET SCALE $\frac{1}{8}$" = 1"

sufficient accessibility so as to require a minimum time for the student to get his drafting equipment from the cabinet, and be stored again at a later time, and (4) an arrangement that will permit the boards and drafting tools to be placed in the cabinet and removed from it with a minimum of difficulty and confusion.

The cabinet may be constructed primarily of plywood, and enameled to suit the color scheme of the laboratory. The hinges should be bolted on and the nuts riveted down. The doors should be fitted with a good cabinet lock, that will insure absolute safety of the stored equipment.

The efficiency of this cabinet is in the storage of drafting equipment and tools, where they can be easily checked and all under the protection of one lock. The cabinet should be located near the door, to provide accessibility for the first class in the morning and returning to storage by the last class in the day.

Part F

SUN FRAME FOR REPRODUCTION AND DUPLICATION OF DRAWINGS

There are many methods of printing Blueprints, Ozalid prints, Van Dyke prints, and BW process. The simplest method is the use of a sun frame, Fig. 18, which contains both the tracing and the sensitized paper and is exposed to the rays of the sun or to bright actinic light.

Making the Sun Frame: The size of the sun frame should be determined by the maximum size of prints to meet the individual needs of the drafting laboratory. It is well to construct the frame of a hard wood, to withstand the natural wear involved in making prints. A first grade, double strength glass should be selected for the front of the frame. The glass is held in place to the edge of the frame with a molding, securely held in place with flat head screws. This allows for easy replacement in case of broken glass. A dark felt pad, approximately 1/4 in. in thickness is desirable. This helps to equalize the pressure on the back of the sensitized paper against the tracing or negative. A word of caution is added; it is advisable to secure a felt pad that does not allow fibers of the material to break away from the pad and lodge between the glass and the tracing. This causes an undue amount of annoyance and results in the disfiguration of the print. The plywood backing should be selected for having a surface that is not in wind. Type 302 stainless steel is a suitable material to form the springs. When the clamping arm is fastened in place, the springs equalize the pressure evenly over the surface of the glass. A natural finish may be applied to the frame to add to the general appearance.

Procedure for Making a Print: The procedure for making a print in the sun frame is as follows:

1. Place the frame on a table or flat surface with the glass or front side down.
2. Remove the back of the frame.
3. Place the translucent copy, to be reproduced, in the frame with the inked or printed side toward the glass.
4. Place the sensitized paper on the translucent copy with the coated side down.
5. Place the back on the frame, making certain that the sensitized and translucent copy are smooth and in line.

6. Then place the frame in the sunlight or under a bright actinic light.
7. Time for exposure will depend on the intensity of the light, quality and type of sensitized paper.
8. Remove the print and develop according to the directions that accompany the type of sensitized paper being used.

Limitations: The use of the sun frame is most often used where the cost of installing modern reproduction equipment is prohibitive. This method is suitable for small prints, but is entirely inadequate for use in industrial plants where prints as large as 12 or 15 feet long are very common. The use of a sun frame for a great number of prints is highly undesirable, as it is necessary to have proper intensity of sunlight available for a satisfactory print.

It may be concluded that use of the sun frame will meet the reproduction requirements of the instructor and students in the small drafting laboratory. There are cases where the work is of such nature and quantity that the purchase of a reproduction printer would be justified.

Part G

DEVELOPER FOR OZALID PRINTS

The developing of Ozalid prints is a very simple process. It requires a very minimum of equipment for the process. The writer developed his first prints in a carbide can, resting on the bath room heater for a source of heat. The aqua ammonia was placed on the inside in a small can, with the exposed prints dropped in around the can of ammonia. This produced very good prints, however, every time the lid was removed from the carbide can, a large volume of the ammonia fumes would escape. This was due to the fact that aqua ammonia fumes are one-half the weight of air. Then, the reaching into the can for the prints caused the skin on the writer's hands to dry and scale off. Considerable thought was given to modernizing the developer, something that would eliminate the difficulties encountered with the use of the carbide can.

New Design: The writer, after experimenting, collected the necessary materials and assembled the new developer, as shown in Fig. 19. A low cost, low heat method was solved by the use of a 200 watt incandescent lamp bulb. This supplies the necessary heat, which rises from the lighted lamp, penetrating the floor plate of galvanized iron which supports the small can of aqua ammonia. The top was made to telescope, much the same as a galvanized iron chicken waterer. This eliminated the loss of ammonia fumes every time the developer was opened, as the fumes would travel upward with the telescoping outside container. The adding of undeveloped prints to the developer and the replacing of the telescoping cover will replace the ammonia fumes in the developer, and agitate the fumes around the prints. The aqua ammonia is changed into a heated vapor, which is essential for the development of such prints.

For convenience of moving the developer around, as well as for support of the heat unit and telescoping cans, a functional stand was added.

There are perhaps other methods of developing prints by the ammonia vapor process, which may work equally as well. The writer, however, will use this developer in developing the prints that makes up

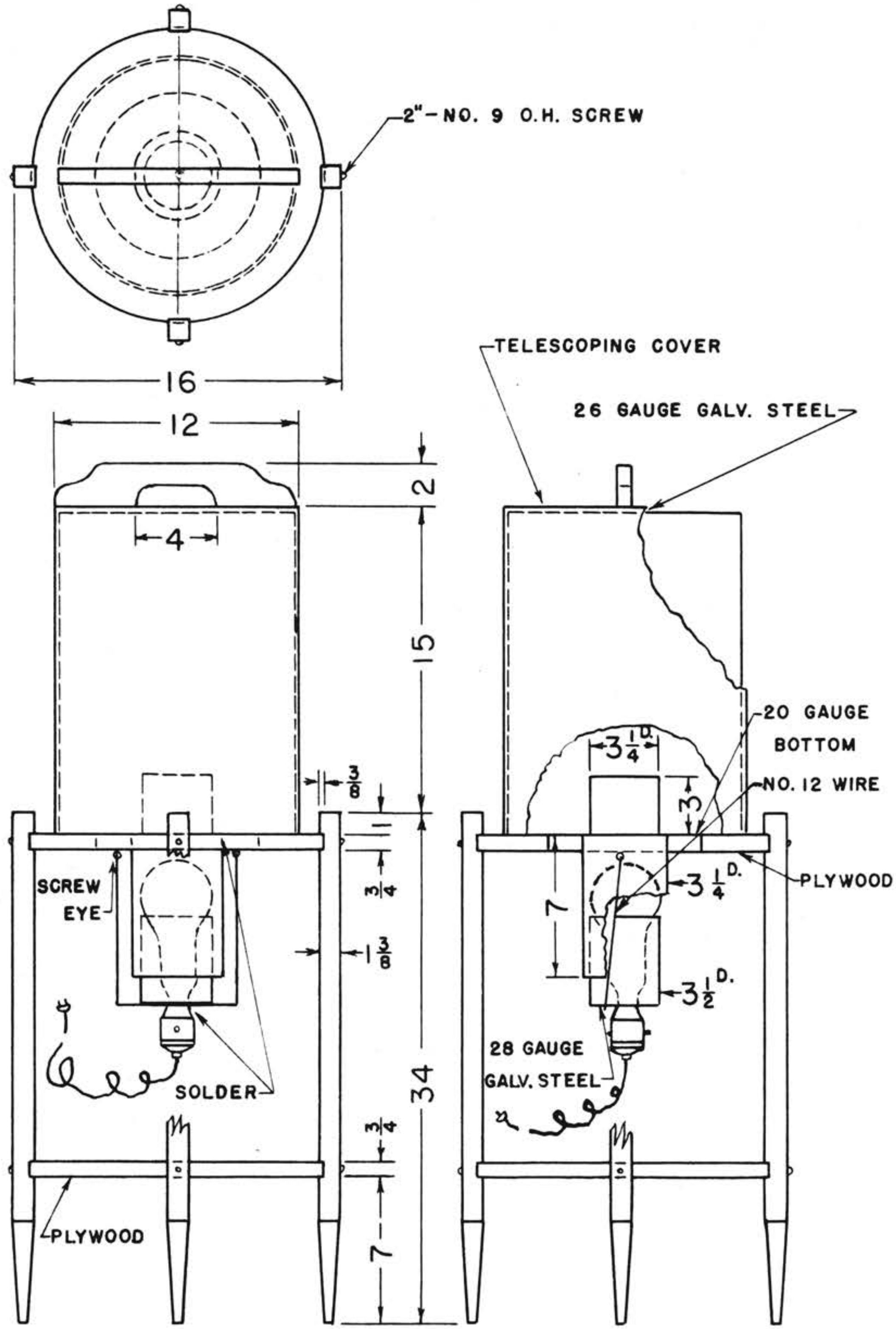


FIG. 19 DEVELOPER FOR OZALID PRINTS

SCALE 1/8" = 1"

the pages of this thesis.

Part H

HECTOGRAPH FRAME

The duplication of a few written or typed articles, or drawing problems maybe easily accomplished on the hectograph, Fig. 20. The simplicity of the operation, the cost of construction, low maintenance upkeep, and speed of duplication should make the hectograph a favorite with the drafting instructor. Made with two gelatin surfaces, the work maybe speeded up because two or more copies may be made at the same time. By the folding of the frame like a book, the hectograph may be stored away free from dust and in a minimum of space.

Construction: The end and side members of the frames are made of 5/8 by 1 in. hard wood strips. The corners are mitered and provided with a spline for additional strength. The inner edges of the frame are beveled to lock the gelatin in the wood pan. The two frames are glued to two pieces of prestwood to form the top and bottom of the hectograph, when closed. It is advisable to give added reinforcement to the glued joint, by the addition of oval head screws. The frames are hinged together and provided with a locking device. A natural finish, added to the outside of the frame, will greatly add to the appearance. The construction of a roller, as shown in Fig. 20, will add to the ease of making the master copy smooth on the gelatin surface.

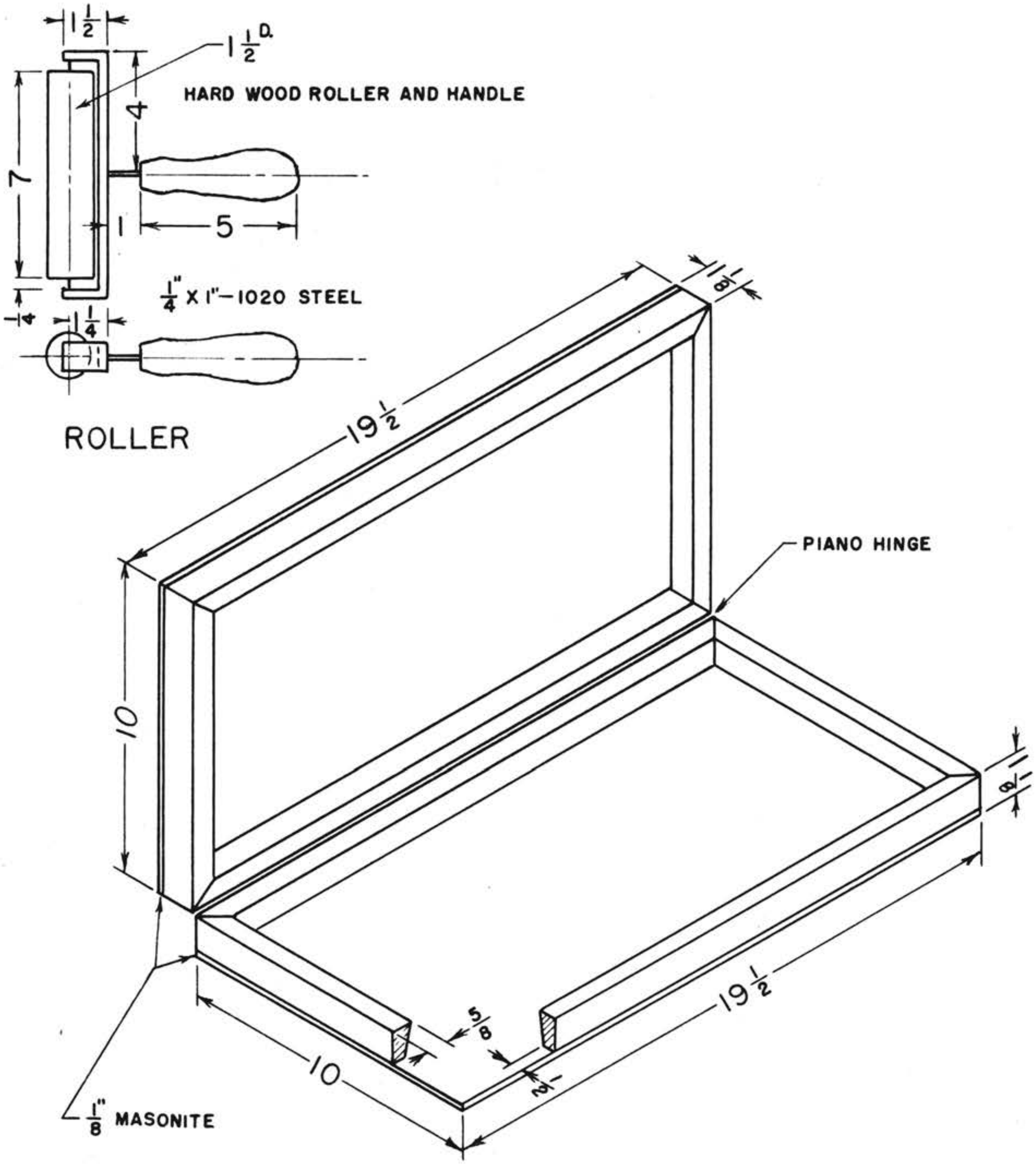


FIG. 20 HECTOGRAPH FRAME SCALE 3/16" = 1"

Part I

T-SQUARE CLAMP

The T-square clamp, Fig. 21, is found very useful in repairing T-squares for drafting classes. It happens frequently that boys drop their T-squares, with the result that the head of the square is usually broken loose from the blade.

Use and Construction: With this clamp, it is a simple matter for the drafting student to remove the screws, scrap the glue, and drill new holes for the screws if necessary. Glue is then applied to the surfaces between the head and the blade. The head and blade of the T-square is clamped in proper position and the screws are set in the holes provided for them. When the glue is dry, the T-square is removed from the clamp and will be found to be as valuable as before the T-square was dropped.

The clamp is simple to construct, and provides a much needed piece of equipment for the drafting room. Skill in squaring the material, turning the wood discs, and placing the various pieces in their proper relation are the only requisites.

It is suggested that the base and discs be made of 3/4 in., 5 ply, and the rest of maple or similar hard wood. Structural sizes and details are shown in Fig. 21.

After the T-square clamp is constructed, surplus glue should be removed and the surfaces thoroughly sanded. A coat of warm linseed oil should be applied to all surfaces and rubbed in well. After the linseed oil is thoroughly dry, a paste or liquid wax should be applied and polished. This kind of a finish will keep any surplus glue,

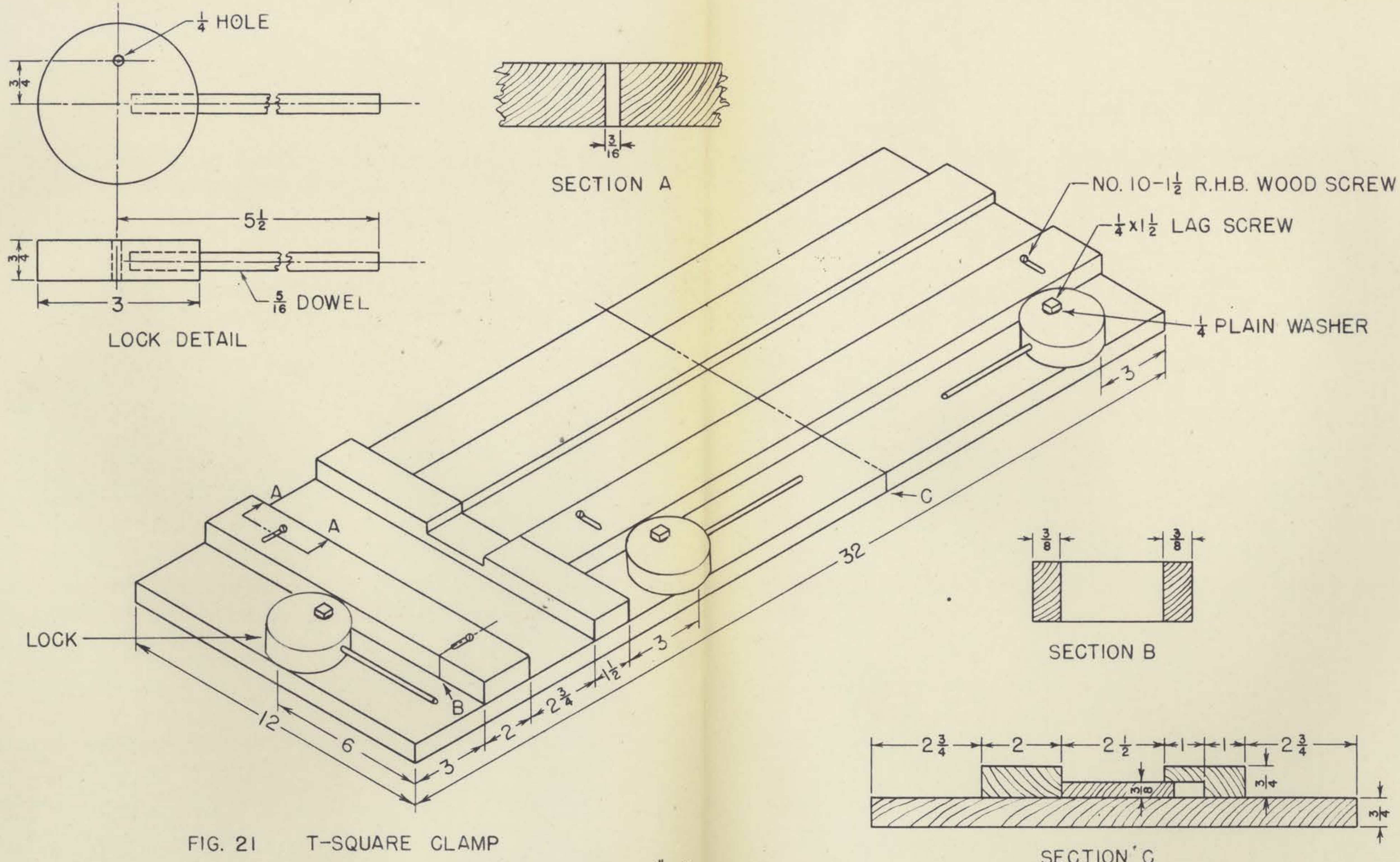


FIG. 21 T-SQUARE CLAMP

SCALE $\frac{1}{4}$" = 1"

resulting from T-square repair, from adhering to the surface of the clamp.

Conclusion: Drafting laboratories, planned and equipped, as suggested in this chapter will meet the requirements of a well planned Industrial Arts Program. The planning provides for flexibility in the various courses that may be taught in the drafting laboratory. There is adequate space for drafting, and facilities for good workmanship on the part of the student is available. The teaching conditions are right for making the most out of what drafting has to offer in adding to the desirable experiences of the student.

CHAPTER 5

SUMMARY AND CONCLUSIONS

From reading the title of this thesis, it will be noted that the problem deals with mechanical teaching aids. This work has been done in an effort to compile material which will assist the industrial arts instructor in the organization and administration of a drafting department. Assumptions were eliminated and earnest effort was made to provide accurate data. A large part of the references and quotations came from leaders in their respective fields.

Summary: To justify continued place in the curriculum of our public schools, a subject must be one of content accepted as valuable for the students who pursue it and one of method so effective as to insure reasonable mastery of the content. Drafting is one of the industrial subjects introduced early in the movement for practical offerings and is today universally taught where industrial arts is offered in our public schools. Because it is so widely presented, it is quite logical and necessary that attention be given to basic studies in this field. We need factual evidence in order to recommend improvements in its materials and methods.

As the industrial arts instructor extends his knowledge of what and how to teach, he is forced to the conclusion that past and present practices are as varied as the number of instructors. The field of drafting is not unique in this respect. Very few attempts have been made to establish the superiority of any given method or procedure. Since drafting instructors are attempting to prepare their drafting students to take their place and to function adequately in society, they fail in their duty if they do not investigate all possible questions relating to worth while subject matter and organization.

The objectives of drafting should place it in every school curriculum and justify the teaching of the subject. Students gain educational values and social habits not otherwise acquired. It is an aid in meeting life experiences.

Textbooks should be used as an aid to the student, and to the instructor of drafting. However, they should be evaluated to determine their suitability. Although methods of teaching drafting seem to be limited, much instructional material may be placed before the student. The instructional material may easily be presented through the extensive use of one or more of the reproduction and duplication methods mentioned in this thesis. The writer has made use of extensive presentation of instructional material by one of the methods of copying. The continuity of a drafting course can be maintained through the intelligent presentation of well written instruction sheets.

Conclusions: Progress in the development of a drafting laboratory that is functional in the modern industrial arts program has been relatively slow. Perhaps this is true because the drafting instructor has been subjected to the school of tradition and afraid of any new trends. The drafting laboratory should be so organized in regard to the general arrangement, equipment, and supplies, that it can be judged on the basis of capacity, utility, speed and such other qualities as might increase production and quality of the work.

The instructional materials which most instructors need are the kind which will permit the individual student to progress with a minimum of supervision and instruction time on the part of the instructor.

Through the use of standard instruction sheets, for all assignments, which emphasizes objective, the materials to be used, and procedures to be followed, the student is led through the various phases of drafting skill development. Understanding is enhanced by the many teaching aids which high light important details in drafting.

Instructors of drafting should be constantly on the lookout for new techniques, teaching aids, and equipment, which will increase their ability to teach, understandingly, knowledge and skill to their students. This is not always easy; antiquated equipment, crowded schedules, and many other factors have in many cases, prevented them from doing this job as well as it should be done. If the students are taught in a modern, up-to-date laboratory, due to this experience with modern planning and techniques, it may help them make better adjustments and thereby become more useful and valuable citizens.

> "True it is that scholars are not yet accustomed to books in typescript, illustrations in blueprint, nor to many of the varieties of product that technology now puts at their disposal. If they can but accommodate themselves to the new techniques, important barriers to intellectual intercourse can be made to fall."
>
> (Author unknown)

BIBLIOGRAPHY

1. Agner, Peter, L., Fundamentals of Mimeograph Stencil Duplication, School Department, A. B. Dick Company, Chicago, Illinois, 1947, 7[illegible] pages.

2. Alexander, F. W., "The Duplicating Process," Business Education World, [illegible]: 27[illegible]-[illegible], January 1947.

3. Alexander, F. W., "The Duplicating Process," Business Education World, [illegible]: 358-3[illegible], March 1947.

4. Bedker, R. F., "Philosophy and Objectives for Mechanical Drawing," Industrial Arts and Vocational Education, 27: 373-37[illegible], November 193[illegible].

5. Brahdy, Joseph, Blueprint Reading, McGraw-Hill Book Company, New York, 19[illegible], 1[illegible] pages.

6. Brinkley, Robert C., Manual on Methods of Reproducing Research Materials, Edward Brothers, Inc., Ann Arbor, Michigan, 193[illegible], [illegible]07 pages.

7. Chickering, Charlotte Deegan, Business Education in Transition, The Commercial Education Association of the City of New York and Vicinity, New York, Fifteenth Yearbook, 1944-1945, 29[illegible] pages.

8. Crispin, Frederic Swing, Dictionary of Technical Terms, The Bruce Publishing Company, Milwaukee, Wisconsin, 194[illegible], [illegible] pages.

9. Emery, James N., "The Duplicator Goes to School," Instructor, [illegible]: [illegible]4, 71, April 194[illegible].

10. Ericson, Emmanuel E., Teaching the Industrial Arts, The Manual Arts Press, Peoria, Illinois, 1940, 3[illegible]4 pages.

11. Estabrooke, Lt. Edward [illegible] and Karch, Lt. R. Randolph, Teaching Techniques, The Bruce Pulbishing Comoany, Milwaukee, Wisconsin, 1943, [illegible] pages.

12. Friedlander, H. A., "The Duplicating Process." Journal of Business Education, 16: [illegible]-2[illegible], October, 1940.

13. Fryklund, Verne C., Trade and Job Analysis, The Bruce Publishing Company, Milwaukee, Wisconsin, 1947, 171 pages.

14. Gregor, Frank, "Ditto Duplication." National Business Education, 10: 53, March 194[illegible].

15. Green, Daniel, "Drawing in the American Way of Life," Industrial Arts and Vocational Education, 34: 36[illegible]-367, October 194[illegible].

16. Hanley, Edmund C., "Hectograph," Popular Science Monthly, 135: 193, November 1939.

17. Hinkle, G. A., The Aluna Process, Field Information Agency, Technical, United States Department of Commerce, Washington D. C., June 10, 1946, 7 pages. (Filed in Document Room, Oklahoma A. & M. Library)

18. Hinkel, G. A., Photo-Reproduction Research of Kalle and Company, Office of Military Government for Germany (US), Microfilmed by The Library of Crongress Photoduplication Service, June 10, 1946, 38 pages. (Filed in Reference Room, Oklahoma A. & M. Library)

19. Hopwood, Ralph F., "Portable Drafting Blackboard," Industrial Arts and Vocational Education, 36: 301, September [illegible]

20. Huff, W. F., "Interesting the Student in Mechanical Drafting," Industrial Arts and Vocational Education, 35: 30, March 1946.

21. Jensen, J. Norman, "Early History of Blueprinting," Architectural Record, 71: 355, May 1932.

22. Johnson, William H., and Fenn, Isadore M., Fundamentals of Industrial Arts and Vocational Education, The Goodheart-Willcox Company, Inc., 1943, 138 pages.

23. Jones, Franklin D., Mechanical Drawing, The Industrial Press, New York, 1941, 342 pages.

24. Kane, Joseph Nathan, Famous First Facts, The H. W. Wilson Company, New York, 1933, 757 pages.

25. Klenke, W. W. and Hayes, C. J., Elementary Mechanical Drawing, International Textbook Co., Scranton, Pennsylvania, 194[illegible], 250 pages.

26. Leighbody, Gerald B., Methods of Teaching Industrial Subjects, Delmar Publishers, Inc., Albandy, New York, 1946, 178 pages.

27. Lucius, Brother, "Improving Instruction in the Use of Machine Duplicators," Business Education World, 27: 92-94, October 1946.

28. Luzadder, Warren J., Engineering Drawing, Prentice-Hall, Inc., New York, 1946, 683 pages.

29. McGlamery, Kenneth W., "Industrial Drawing as an Indispensable in the Industrial Arts Program," An unpublished Master's report, Oklahoma A. & M., 1947, 54 pages.

30. Miller, G. H. "Mimeograph Duplication," National Business Education, 14: 33-34, March 1942

31. Miller, George H., Office Duplicating, Produced by Walter Darwin Teague on Mimeograph Duplicator, 1939, 126 pages.

32. Murry, R. E., "Tracing Table," Industrial Arts and Vocational Education, 26: 31, January 1937.

33. Neuner, John J. W. and Haynes, Benjamin R., Office Management and Practice, South-Western Publishing Company, Dallas, Texas, 1941, 550 pages.

34. Newkirk, Louis V. and Johnson, William H., The Industrial Arts Program, The Macmillan Company, New York, 1948, 357 pages.

35. Newton, F. N. jr., "Reproduction Methods used in the Drafting Room," Industrial Arts and Vocational Education, 37: 30A-34A, September 1948.

36. Ozalid, How to get the most Value with Ozalid, Division of General Aniline and Film Corporation, Johnson City, New York, 1946, 48 pages.

37. Petraglia, Frank A., "How to Improve Instruction Sheets," Vocational Instructor's Handbook, Fall, 1944, 394 pages.

38. Perdue, G. R., Ozalid Light-Sensitive Materials, British Intelligence Objectives Sub-Committee, 32, Bryanston Square, W. 1., 10 pages. (Filed in Document Room, Oklahoma A. & M. Library)

39. Roehl, L. M., "Resourcefulness," Industrial Arts and Vocational Education, 24: 27, January 1937.

40. Scientific American, "Dry Print, Positive Blue Prints," Scientific American, 162, 170, March 1940.

41. Struck, F. Theodore, Creative Teaching, John Wiley and Sons, Inc., New York, 1938, 623 pages.

42. Webster and Merriam, Webster's Collegiate Dictionary, G. & C. Merriam Co., Springfield, Massachusetts, 1947, 1275 pages.

43. Wilber, Gordon O., Industrial Arts in General Education, International Textbook Company, Scranton, Pennsylvania, 1948, 362 pages.

44. Wright, William N., A Simple Guide to Blueprint Reading, Craftsman Press, Inc., Seattle, Washington, 1941, 199 pages.

Typed, and Reproduced Entirely by the Ozalid Process by: Rex A. Miles