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**PHYSICAL FACILITIES, TOOLS AND
TEACHING AIDS AS A
MEANS OF IMPROVING DRAFTING INSTRUCTION**

William E. Wyatt

A plan "A" paper
written in partial fulfillment of
the requirements for the degree of

**MASTER OF SCIENCE
IN
EDUCATION**

**EASTERN ILLINOIS UNIVERSITY
July 9, 1961**

Approved

Approved

PREFACE

This paper was written because the author feels the quality of work done and the teaching job performed in the school drafting room can be greatly improved by a knowledge of, and use of, available physical facilities, tools and teaching aids.

I wish to give special thanks to the Reynolds Spring Company, Vincennes, Indiana, and to Mr. John Bartrum and Mr. John Samoluk, of the engineering department of this firm. Their patience with the many questions and frequent visits has been greatly appreciated.

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Introduction

The history of man has been a constant striving to improve his position, and the environment in which he lives. This paper is concerned with the progress of man, and his ability to improve his way of life by the design and production of tangible products to make his life more enjoyable and worthwhile.

Statement of Problem

The problem to be considered had it's beginnings because of the dawning of the industrial age, or as it is usually referred to, the Industrial Revolution. Man has progressed from the Industrial Revolution, where he built and worked on machines to produce tangible goods, to a new Industrial Revolution of Automation. This new revolution has created many new opportunities and products that would not have been possible with older methods of production. As items that are produced become more complex, the designing of the machines to produce them become more difficult. The working drawings for these machines, and the products they produce, are also becoming more complicated. Some progress has been made in the ideas, tools and techniques for creating working drawings of objects to be produced. However, man is always slow and resistant to any change from his established patterns of behavior. Modern materials and methods are slowly being evolved by most engineering departments of large manufacturing corporations.

Need for the Study

The primary concern of this paper is: How can the physical facilities of the school drafting room, the tools, supplies and teaching devices, be utilized to do a more efficient job of teaching drafting?

Many people are working with basic equipment - drawing board, tee square and stool - which is virtually identical with that which was in common use 60 years ago, and very little different from that on which Sir Christopher Wren laid out plans for St. Paul's Cathedral and James Watt prepared drawings for his early steam engines.¹

Teachers of drafting need to analyze the work that is being done in industry by draftsmen to determine the material being presented to the student of drafting. Is this the information and techniques used when they become engaged in drafting positions in industry? Each teacher should keep abreast of all developments in the specific area being taught.

Methods of Collecting Data

The information for the paper was gathered from industry, the personal experiences of teachers of drafting, a study of textbooks and periodicals dealing with drafting, manufacturers of drafting equipment and supplies, and the author's own personal experiences in the field of drafting.

¹L. Bruce Archer, "The Designers Equipment," Design, 122 (February, 1959), p. 51.

Physical Facilities of the School Drafting Room

Planning of the Room

Too many times the drafting room has been just any room in the school building, with a few benches, a few stools and a text from which to copy outmoded problems or exercises. Great care should go into the planning of the physical facilities, the equipment that is to be used, and the material that is to be presented. The appearance of the school drafting room should correspond as nearly as possible to that of an industrial drafting room.

The size of the room will vary with the individual situation. A rectangular room with an adequate amount of space to house the necessary equipment and students without being crowded is recommended. M. L. Englehart recommends fifty square feet per pupil.¹ The number of students to be taught and the equipment to be placed in the room are necessary bits of information that should be known before the size of the room is determined. Too many times the reverse procedure is followed. A room is secured, equipment and supplies are acquired, and then a program is tailored to fit the materials on hand rather than the needs of the students.

Obviously, mere dimensional requirements are not satisfactory bases for planning. A standard class size has been a major

¹M. L. Englehart, M. L. Englehart Jr., and Stanton Leggett, Planning Secondary School Buildings (New York: Reinhold Publishing Corporation, 1949), p. 86.

determinant of the spaces provided in many schoolhouses. . . . the wider freedom of the classroom should be given greater consideration in the planning of room sizes than the more dimensional requirements which unwisely have been incorporated in law.¹

Color for the Room

It is recommended procedure to have the colors in the room harmonize with each other. A light cheerful room is more conducive to learning than a dark dismal room. It is possible to emphasize displays, storage areas and danger zones by the use of bright contrasting colors.

Lighting for the Room

With the advent of fluorescent lighting less emphasis can be placed upon the necessity of a given quantity of natural light.

Tests in illumination have proven that the natural light entering through the classroom windows is seldom sufficient over more than half the room and artificial supplementary lighting must be used on the corridor side. Thus the traditional standard of twice the height equals the width of the room also is being affected by experience and scientific tests.²

It is accepted practice to place the fluorescent fixtures diagonally across the room, and to end, so they form one continuous ribbon of light from one side of the room to the other. The rows are spaced about six feet apart over the total length of the room. Most of the fixtures observed have been of the double strip type. Two kinds of fixtures are in common use, one having an exposed bulb or bulbs suspended below a white reflector, and the other enclosed with an egg crate arrangement, either of white steel or translucent plastic. Another

¹Ibid., p. 100.

²Ibid.

type is a luminous ceiling of translucent plastic with fluorescent lights above it. This ceiling has several disadvantages; the initial cost is much greater than the strip lighting, and more current is required to reach the desired level of illumination. Fluorescent lights do not generate as much heat as regular incandescent bulbs, but the large quantity of bulbs required for this type of lighting generate more heat than the conventional strip lighting. Also, this ceiling has a tendency to collect bugs and dirt. A ceiling similar to the one described above is used by the drafting department of Snap On Tools Corporation in their Mt. Carmel, Illinois plant.

Ventilation for the Room

Windows to supply ventilation are still usually found in drafting rooms in schools and industry. This is not as important as it once was because of the use of air conditioning and ventilating systems. One example of the absence of natural light and ventilation is the drafting and engineering offices of the Reynolds Spring Company, Vincennes, Indiana. This company relies entirely upon both artificial light and mechanical ventilation. There are no windows present in these rooms. This arrangement is not recommended for small rooms because of the likelihood of the development of claustrophobia by the users of the room.

The Furniture of the Room

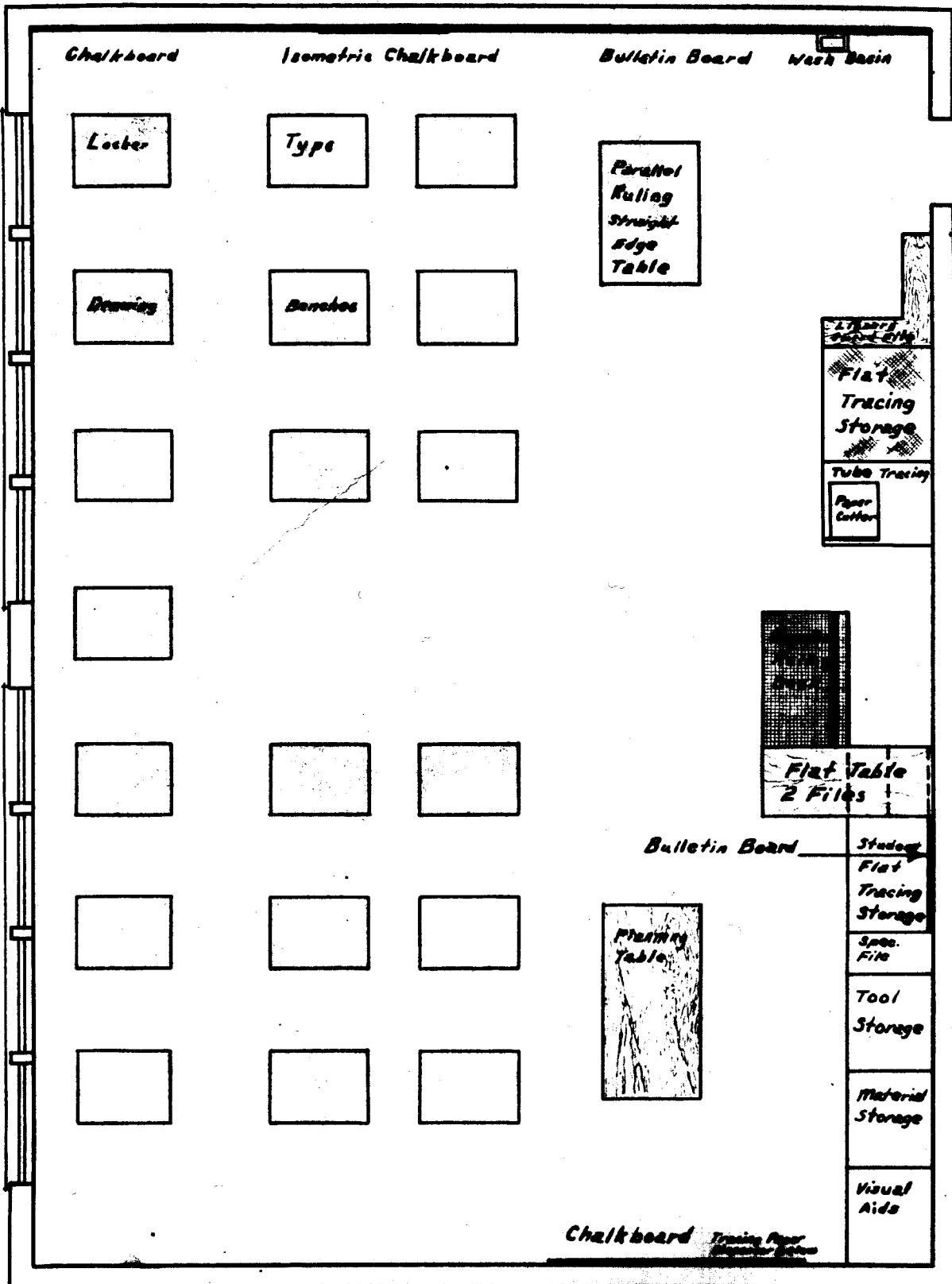
Placement of Furniture

Traditionally the benches have been in a line, one behind the other and evenly spaced side by side across the room. This pattern is slowly being changed, and the teachers of drafting are beginning to use

a more logical arrangement of the furniture in the room. For example, if all the aisles in the room are of the same width, each aisle would be as easy or as difficult to use as the adjoining aisle. With a more logical placement of furniture, the aisles having the most traffic would be wider than the spaces between the benches where no traffic is desired. By the placement of furniture the teacher can channel the traffic and the activity of the room to the desired areas. An example of how traffic can be channeled by the placement of furniture will be noted in illustration 1, page 7, showing a modern drafting room and the placement of furniture within the room. Note the space between the windows and the first row of benches. Approximately eighteen inches is left between the first row and the windows. This is done to channel the traffic away from this area. The rows of benches in the center of the room are placed close together with a wide aisle on either side to channel the flow of traffic, and also to conserve floor space. Note the wide area in the center of room leading from the door past the library center, past the teacher's desk and work area and on to the storage area. This furniture arrangement helps direct the flow of traffic past the teacher's desk, but the aisles are wide enough to eliminate most of the congestion. It is suggested that the furniture be arranged to fit the needs of the group and not be arranged according to any established order of arrangement.

Work Surfaces

A study by L. Bruce Archer revealed that the furniture of a room has an effect upon the quality of work that is being done. Most drafting rooms in schools use a flat, or only slightly inclined drawing table.



Modern Drafting Room Floor Plan

Figure 1

Perception is better when erect, poor when leaning over the work. . . . There is evidence that between 50 and 75 percent of the errors and inaccuracies which occur on engineering drawings are in a region near the top of the drawing sheet where bad posture has blunted perception.¹

This study also found that more energy is required to work at a horizontal rather than a vertical board. One objection to the vertical board is the necessity of having another place to keep the drawing equipment that is being used. Two common ways to solve this problem are to have an L shaped table on the left side of the drawing table, or when the benches are placed in rows the draftsman uses the flat table behind him when the drawing board to the rear has been tilted into work position. Tall benches and stools appear to be more satisfactory than shorter ones with the draftsman half standing, half sitting on the stool. They give more freedom of movement with a minimum of effort.

Bulletin Boards

It is accepted practice to have a bulletin board in each class room of the school. This is no assurance that teaching will be of a better caliber because of its presence. Many bulletin boards are collecting dust, with nothing on them. Or even worse, the materials have not been kept up to date. A student cannot be expected to look at a bulletin board if the information is never changed. The information placed on the bulletin board should be left on the board only long enough for the people in the class to see it. The materials to be placed on a bulletin board should be displayed in an attractive, eye catching manner. If the materials on display are cared for in a

¹Archer, op. cit., p. 53.

haphazard manner the student may do his work in the same way and think this is what is expected of him.

Storage Facilities

The organization and storage of materials can also contribute to the quality of work that is being done. If the physical appearance of the room is kept in a haphazard manner there is reason to believe the work will be done in the same manner. Very few school buildings, especially the older ones, have adequate built-in storage facilities. This is more often an excuse than a reason for not having materials organized in a desirable manner. Some kind of storage can always be found if a little imagination is used. Most schools will provide enough storage cabinets if requests are made for them. Sometimes wooden shelving must be substituted. If rough shelving cannot be provided, crating materials are better than nothing at all. If no storage facilities can be found, the stacks of material can at least have system and order about them.

Planning Tables and Areas

One deficiency of most school drafting rooms is the absence of adequate planning areas and tables. It is very desirable to have a planning table large enough to accommodate at least one fourth of the students in the class. If possible, a chalk board and bulletin board should be in the immediate vicinity. Pertinent information for the discussion or planning session can then be placed on the boards for all to see.

Drafting Tools and Equipment

Drafting Machines

As stated earlier, many people are still using Tee Squares and drawing boards much the same as they did sixty years ago. This is not as it should be. It is not advocated that all schools large and small go out immediately and buy the biggest and best drafting machine available for each of the students, but an attempt should be made to keep abreast of all the current developments and make an attempt to become acquainted with the tools and processes that are currently being used by industry. Many of the students currently in drafting classes will work in industry when they leave school, therefore it is important that they be given experiences on equipment they will be using, and learn methods that are used by industry.

A survey conducted by Stratford High School in Stratford, Connecticut, and published in the May, 1955 issue of Industrial Arts and Vocational Education magazine revealed that:

Seventy six percent of the industrial drafting departments questioned, use drafting machines for their design work. Sixty three percent of these exclusively, while only two percent use T squares. Thus the drafting machine today has become the overwhelming choice of industry.¹

It is logical from the results of the survey that the drafting machine can no longer be ignored as a major tool of the school drafting room.

¹Herbert W. Yankee, "Let's Make Drafting Realistic," Industrial Arts and Vocational Education, 44 (May, 1955), p. 155.

Many teachers feel that if the student is taught with the T square and triangles he can readily adapt himself to the use of a drafting machine. This point of view is not held by the heads of industrial drafting departments, according to Robert A. Goulder.

Virtually every industrial-drafting department head interviewed felt that the efficiency of the draftsmen in his department was considerably impaired by insufficient understanding of the use, operation, and adjustment of their drafting machines. Constant teaching of the T square and triangles in early life formed mental and physical habits detrimental to their efficient use of the drafting machine. For example, many draftsmen continue to use a triangle as a vertical rule with the horizontal scale of the drafting machine, completely overlooking the vertical drafting machine scale, thereby lowering the value potential of the drafting machine up to 50 percent.¹

The cost of a drafting machine is quite high, with the better models costing over 100 dollars. One could not justify the purchase of one for each student in a drafting class in a small school, but one or two could certainly be justified so the student can have at least some experience on this type of equipment.

Most of the older textbooks ignore the drafting machine completely although the newer texts do make some reference to the drafting machine. The Universal Drafting Machine Company, 7960 Loraine Avenue, Cleveland 2, Ohio, offers a pamphlet to teachers upon request, entitled, "Drafting Machine Practice."

Parallel-Ruling Straightedge

Industry also uses the parallel-ruling straightedge quite extensively. This device is used to draw horizontal, straight lines.

¹Robert A. Goulder, "Drafting Machine Training in the School," Industrial Arts and Vocational Education, 46 (November, 1957), p. 283.

All other conventional instruments are used with this device. A picture of the parallel-ruling straightedge is shown in illustration two.



Parallel-ruling straightedge
Figure 2

A survey conducted by Herbert W. Yankee revealed that: "Twenty two percent of the industrial drafting departments of industry are now using this instrument."¹ Some experience should be given the student on this piece of equipment. One advantage of the parallel-ruling straightedge is the ability to draw long continuous horizontal lines. The major disadvantage of this device is the necessity of having the drawing free of other tools, to allow the straightedge to be moved on the table. The parallel-ruling straightedge is sold attached to a portable drawing

¹Yankee, *op. cit.*, p. 155.

board, and is also built onto a stationary adjustable table. The sizes range from seventeen inches to eight feet in length.

Use of Drawing Instrument Sets

It has been common practice to issue, rent, or have each student buy drafting sets complete with different kinds of ruling pens. From observations of industry, the absence of complete sets has been noted. The only instruments visible are the items that are most frequently used. The adjustable leg compass found in most drawing sets is seldom used by industry.

Center Wheel Bow Compass

The big bow compass with center wheel adjustment is preferred over the adjustable leg type, with the virtual elimination of the adjustable leg compass. The use of this instrument eliminates the need for changing instruments for drawing large and small circles. The center wheel bow compass is also more rigid and less likely to cause errors in the work. Many of the instruments in a typical drawing set are seldom used and can be replaced by attachments to the compass.

Mechanical Lettering Devices

A drawing to be of use must be easily read. According to the survey by Herbert W. Yankee, and published in Industrial Arts and Vocational Education magazine in May, 1955, one of the common weaknesses of prospective employees is the lack of ability to do good lettering work. The particular style of the lettering, or whether it is inclined or vertical, is not as important as its legibility. Poor lettering will frequently cause mistakes on work being done from the print. The use of lettering devices and guides has offered some help with this

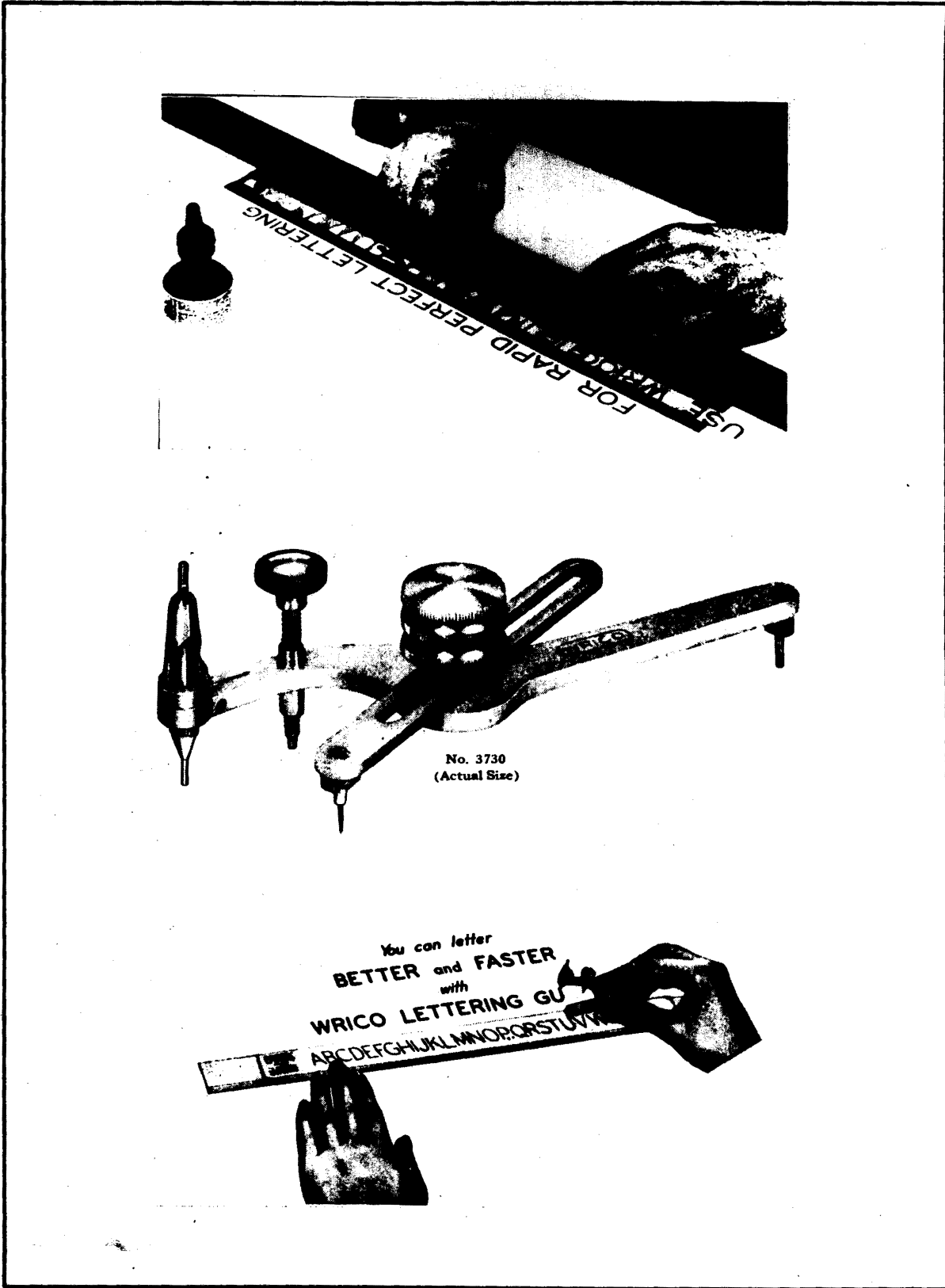
problem. Two such devices are the Wrico and Leroy lettering guides. The Wrico lettering guide is shown in illustration three, page 15. Several different sizes of letters are included in the better sets. These instruments are capable of reproducing the letters in a very desirable manner. The chief drawback of the lettering guides is the great amount of time it takes to use them. They are used chiefly for title blocks and the most important lettering, and the rest is usually done free hand.

Electric Erasers

One of the new tools that is frequently found in industrial drafting rooms is the electric eraser. For doing a lot of erasing on a drawing these machines are very good. However, if the line to be erased is small, it is easier to pick up and use a hand eraser. Two different electric erasers were examined. One company places the switch on the top of the eraser. The other company places the switch on the side of the machine. The author feels the latter arrangement is more satisfactory.

Triangles

Since the great emphasis has been placed upon production rather than artistic ability, many devices have been developed to help the draftsman execute the drawing more rapidly. The use of a larger triangle for large work is one way the draftsman can save time. One continuous line eighteen inches long can be drawn more rapidly than two nine inch lines and the line will probably be better because it is not necessary to splice the line. The adjustable triangle with degree divisions is also a very useful item. Some models of this triangle have



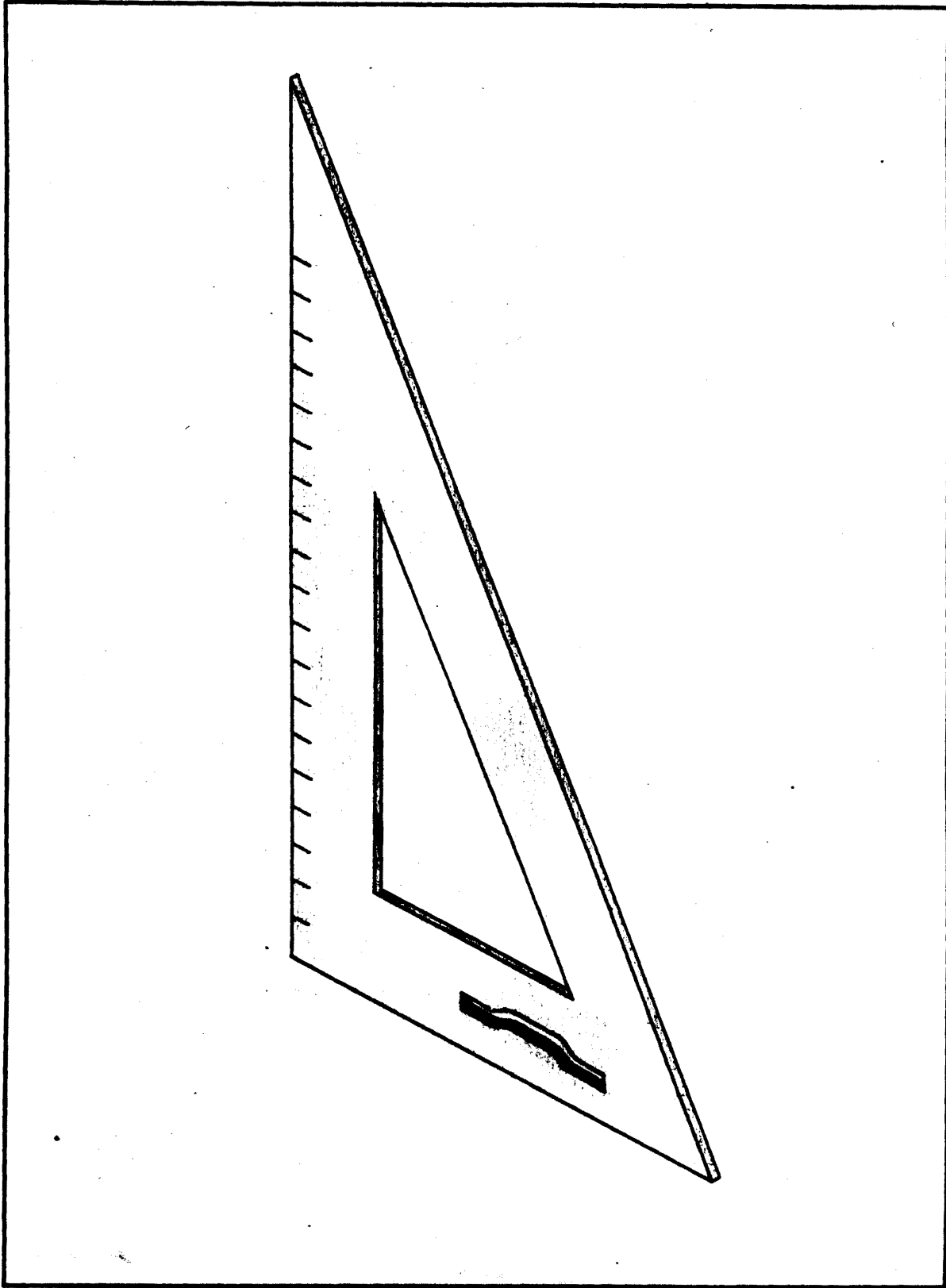
Wrigo Lettering Guide

Figure 3

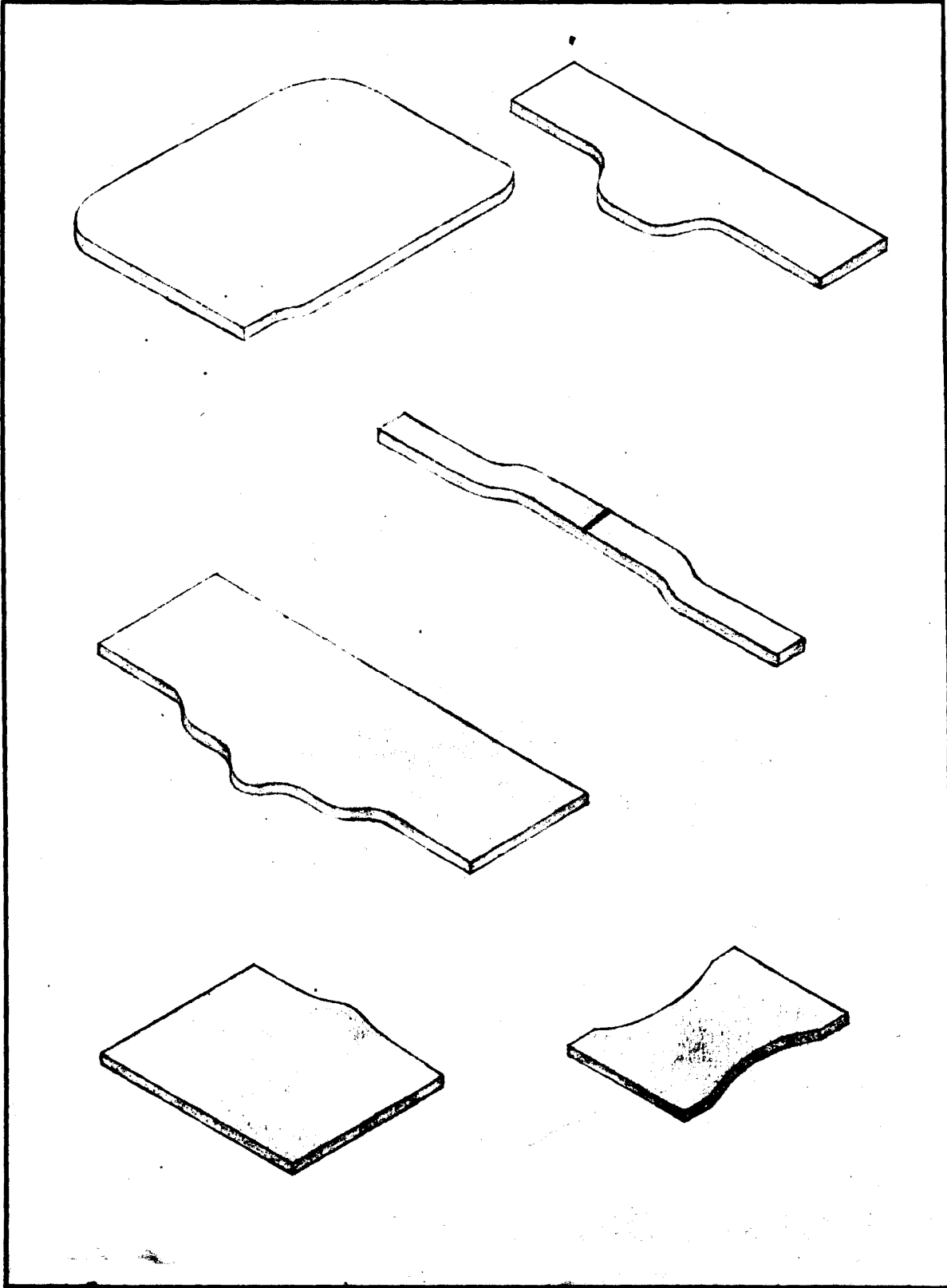
data for the various roof pitches that are used in architectural drafting. One innovation that is very interesting and practical is the cutting of templates for non standard items into the triangles. This is done by the individual as the need for a special shape arises. One such shape that is frequently used in the engineering department of Reynolds Spring Company, Vincennes, Indiana is shown in illustration four, on page 17. Care must be taken when cutting such a template to secure the proper shape. Shown in this same illustration is a method of laying out division marks on the triangle.

Curves and Templates

Curves and templates of many hundreds of shapes and standard parts are manufactured by the various drafting equipment manufacturers and can be found in their respective catalogues. No attempt will be made to describe all of the shapes that are available. Occasionally a shape is needed that no template has been designed to reproduce. Oftentimes it is necessary for the individual to construct templates for his own use. Two materials suitable for the construction of templates are the rigid plastic laminates and one sixteenth inch plexiglass. The plexiglass is slightly more expensive and not nearly as readily available as the plastic laminate. The plexiglass is considered more suitable because of the ease of shaping the part, and also because it is completely transparent. Figure five, on page 18, shows some of the possibilities for the template made by the draftsman, used to draw specific objects. The templates shown are used to draw the spring shape for jigs and fixtures for Reynolds Spring Company, manufacturers of automobile springs for seats. One disadvantage of a template of this type is the difficulty



Template Cut Into Triangle
Figure 4



Home Made Flat Templates

Figure 5

of holding the template when drawing at unusual angles on the paper, especially when doing the drawing without the aid of other instruments. A solution to this problem is shown in figure six, on page 20. The template is made slightly larger and only one shape is placed on the template. The back of the template is heated and raised at an angle of about twenty degrees, thus allowing the user to place the thumb under the template and hold it more securely. The back edge could be left flat as in figure seven, page 20, and a small strip for holding cemented to the top of the template.

Many instructors feel they are not doing an adequate job of teaching unless they are having all the work done with conventional instruments. Any instrument that makes the job easier or better should be used if possible.

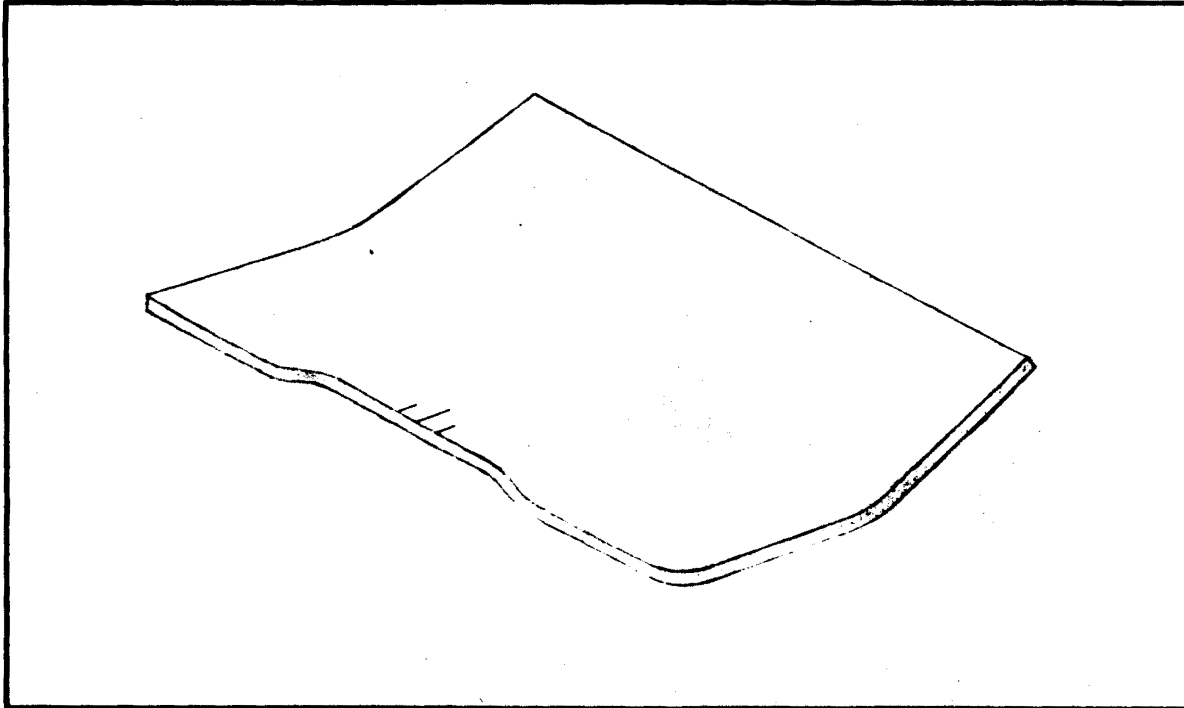
Flat vs. Triangular Scales

The survey by Herbert W. Yankee indicated: "Only 14 percent of draftsmen are still using triangular scales as compared to 62 percent who are using flat scale with two bevels."¹ From the evidence presented there is reason to believe drafting teachers should introduce the use of the flat scales to the drafting students.

Rapidagraph Pens

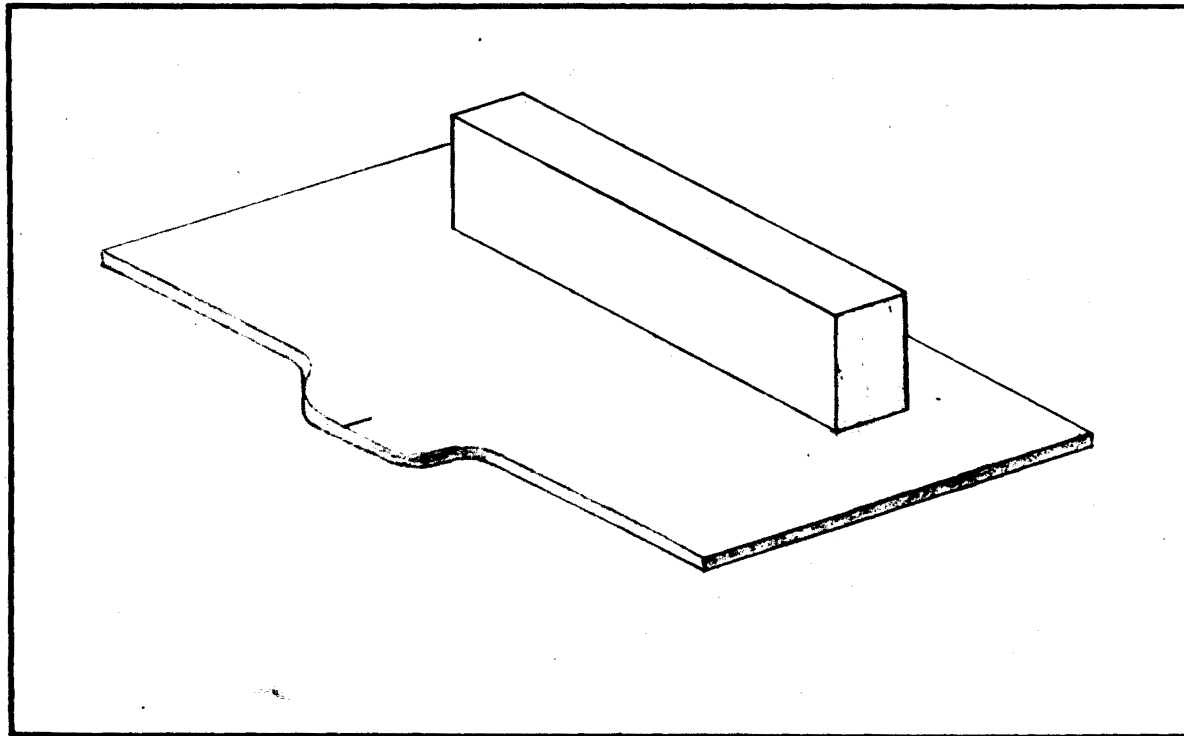
The use of ink for drawing has shown a steady decline over the past few years. This does not mean the use of ink is going to disappear. It is still used by industry for many of the more permanent drawings and is used exclusively for patent office drawings. The great amount

¹Ibid.



Template With Raised Holding Device

Figure 6



Template With Auxiliary Holding Device

Figure 7

of time required to ink a drawing using conventional methods is the primary reason for the change to pencil tracings by industry. The Rapidagraph pen has changed the whole concept of inking drawings. These pens are used in conjunction with templates and a process of tracing around an object is used. This process does not resemble drawing as it is known today. There are two types of Rapidagraph pen. One type is filled like a screw fill fountain pen. The other type has a refillable cartridge. There are seven pens in a complete set. Each pen draws a different line width. The size line width is numbered 00, for the finest line, then size 0, 1, 2, 2½, 3 and 4. Each pen size is color coded on the pen point with a colored stripe around the pen. The cap which has the numbered pen size stamped on the top, also has a color coded band. The quantity of ink flow is accurately controlled with these pens, thus eliminating many of the errors caused by excessive ink as in a conventional ruling pen.

Quality Tools

The idea that anything worth doing is worth doing well applies also to the purchase of drafting equipment. One cannot expect the student to do good work on old or inferior quality tools. There is nothing more frustrating than to try to do a job with tools that will not adequately do the job they were intended to do, no matter how much effort is put forth by the user. It is better to have a few good tools than a lot of poor ones. It is suggested that the basic tools of a good quality be purchased, and as need arises or more funds become available, additional quality tools can be purchased.

Paper, Pencils and Other Supplies

Use of Heavy Bond Paper

It is quite common practice to see an instructor using a heavy bond, or detail paper as the medium upon which the drawings are drawn. After the completion of the drawing it is necessary to transfer the drawing to a tracing paper, vellum or film. Statements by suppliers of drafting supplies and observations in industry indicate the process is entirely different for industry. It will not be argued that a neater drawing can be made if it is first drawn on detail paper and then copied onto a tracing medium. Time and money are the two chief reasons why this method is no longer used by industry. If drafting is to be taught with any similarity to industry, this technique must be abandoned. Some instructors in individual schools have begun to change their attitude toward this practice, and are now having the work done in a more realistic manner.

Tracing Paper

Manufacturers of drafting supplies offer a wide variety of tracing papers. The papers range from a very opaque, light weight bond to very thin transparent vellum. The bond papers are considerably less expensive than the finer grades of transparent papers. Cost will influence greatly the decision as to which is the proper paper for the drawing being done. When the heavier papers are used a much darker line is needed to get good reproduction, and even then the background will probably have some discoloration. One problem encountered during a

visit to J. Sterling Morton High School, Cicero, Illinois was the use of different weights and grades of paper within a single classroom. This can create a problem as the different papers require different amounts of exposure to obtain good reproduction. It is suggested that only one quality of tracing paper be used within a single classroom.

Tracing paper is used primarily for pencil drawings. However, some of the better papers can be used for ink work. Tracing paper can be purchased in large rolls for the larger size drawings, or it can be purchased in any of the standard sizes. It is quite common practice to have border lines and title information pre-printed on the tracing paper. This practice is used quite extensively by industry and to some extent by schools.

Tracing Cloth

Tracing cloth is used primarily for drawings that are to be done with ink. The cost of tracing cloth is quite high, and it is not used to any great extent either by industry or the schools. An instructor usually has the student do one or two drawings on this medium to give him some experience with it. It will be noted upon examination of tracing cloth that one surface is dull and has a slight texture or tooth to it. The other, or back side, has a gloss. The drawing should be done on the dull side of the cloth. When handling tracing cloth, care must be taken to keep the hands off the work as much as is possible. The oils from the hands are not visible on the cloth but they leave a film that keeps the ink from flowing properly. This condition can be remedied somewhat by the use of powder or chalk dust on the surface of the cloth prior to drawing. Care must be taken to the quantity or texture of this material. Too much powder will prevent the line from

flowing properly.

Tracing Film

One of the newer developments in drafting is the use of film for tracing. This drawing medium has many advantages over other materials. One of the advantages of film is its stability, with a minimum of expansion and contraction. Another advantage is its high transparency. The working surface of plastic tracing film has a slightly frosted appearance. The roughness or texture of the drawing surface is to give tooth to the surface to hold the ink from spreading. This material can be used equally well for pencil drawings. The chief drawback to the use of film is the cost of the material.

Transparencies and Intermediate Prints

Transparencies, as the name implies, is the use of several clear plastic sheets laid one over the other to show different stages in the development of an object. They may be used to print confidential information on a drawing without having this information on the master copy. Another valuable use of the overlay technique can be used in the discussion of a drawing by a group of people. Prior to the discussion, a clear plastic film is placed over the original drawing. As the discussion proceeds, recommendations and changes can be noted on the film. The master copy is preserved in its original state. An intermediate print can then be made by running the tracing and film through the machine at the same time. The applications of this material are limited only by the imagination of the user.

A very valuable pamphlet showing the development of transparencies, entitled "Picture Power," is published by the Charles Beseler Company,

East Orange, New Jersey. This pamphlet is available upon request.

Another valuable pamphlet, "Ways to Save Drafting Time With Intermediate Prints," is available from Fredric Post Company.

There are many cases when valuable original drawings cannot, or at least should not, be altered or modified. Yet tracing or re-drawing hours are costly. This problem can often be solved through the use of intermediate.

For purposes of definition, an intermediate is any translucent-based reproduction master printed from an original drawing in order to permit modification and to serve as the basic source of print-making. . . . In addition to drafting room use, these short cuts can be adapted for business and office systems to effect substantial savings in the preparation of originals and reproduction operations.¹

Pencils

The proper pencil to be used will vary with the individual and the job to be performed. However, it is noted there is a tendency by draftsmen in industry to use only one pencil for all the work, thus eliminating the need for changing from one pencil to another. The important development in the use of the pencil is the use of the automatic slip chuck lead holder instead of the more conventional wooden pencil.

Methods of Attaching Paper to the Drawing Board

For many years the standard way of attaching paper to the drawing board was with the use of thumb tacks. This method had many drawbacks, chief of which was the large number of holes left in the drawing board. This method of fastening is being replaced with the use of masking or drafting tape. Besides not leaving holes in the board, the tape leaves a flatter surface to move the instruments across. The tape is also more easily removed from the surface when the work is completed.

¹"Ways to Save Drafting Time with Intermediate Prints," Fredrick Post Company.

Pencil Sharpeners

The standard method of sharpening the pencil for many years has been by the use of the standard draftsman pencil sharpener and sandpaper or the sanding pads, made up of several sheets of sandpaper glued to a wooden base. Some use has been made of files as a sharpening device. More recently the blade type pointer has been developed. The pencil pointing machine is also used quite extensively.

Cleaning and Burnishing the Pencil Tip

After the pencil tip has been sharpened by any of the above methods there is a small quantity of graphite dust left on the tip. This dust must be removed to keep it from getting on the drawing. One method of cleaning the tip is to wad a piece of facial tissue and wipe the tip with it. Another method is to fill a small container with cotton and rotate the pencil tip in the cotton to clean it. A small piece of cloth can be used. One interesting use of the cloth is to fold it very compactly and place a rubber band around it. Instead of wiping gently to remove the dust, the tip of the pencil is revolved quite vigorously. Added strength for the point is supposedly gained by this burnishing of the tip. This idea is based on opinion and not upon any scientific study of the problem. However, it does work very satisfactorily, and leaves the point in very good condition.

Teaching Aids

The use of teaching aids by the drafting instructor can contribute much to the knowledge gained by the student. Some of the devices to be discussed are used by most teachers, and will be mentioned only briefly. Other devices of a more uncommon or unusual nature will be discussed at greater length.

Sample of the Object Being Drawn

One of the most common visual teaching aids in drafting is the use of an actual part of an object. The student keeps this object before him and takes the measurements from the object. This works well for small objects but is of no value for larger objects. This is probably the most simple kind of teaching aid.

Blocks of Various Size and Shapes

Another method very closely related to the above method is the use of small wooden blocks cut into the shape of the object. These can range from very crude objects cut out on the spur of the moment to very detailed and carefully planned objects with a great amount of work of a very high caliber being done on them. The finished visual aid is often very striking because of the outstanding finishes used on them.

Cut Away Models to Show Cross Sections

This teaching aid is much like the first method mentioned in as much as the actual part is often used, with parts of the object cut away to show the interior views. Many times the instructor constructs parts in cross section from wood and paints the different areas in bright

contrasting colors. The part that is to be shown in cross section on the drawing is usually drawn with section lines on the sample. These also range from very crude to very elaborately planned objects.

The Transparent Box

This device is a transparent cube with hinges on each of the panels to show the relationship of views to each other in orthographic projection. The sides, top and bottom fold out flat to show their relationship to each other. These boxes were first made of glass with tape acting as the hinge. It is more common practice now to use clear plexiglass with small hinges either of metal or plastic. The newer type is easier to handle and there is less danger involved than with the glass models. This object is available as a manufactured teaching aid from drafting supply distributors.

Isometric and Graph Paper

Isometric paper is available from most drafting supply distributors. It is a great aid in the teaching of free hand isometric sketching. This paper is usually of a light green tint with a darker green or blue line. Even though the lines are darker than the paper, they are still a very faint line. This paper is available either in long rolls or in standard cut sheet size. It is also available with pre-printed border lines and title blocks.

Graph paper used in drafting is usually ruled with eight divisions to the inch both horizontally and vertically. A very important development in graph paper is the plastic coated board covers. These covers are ruled in eighths as conventional graph paper with the eighth division ruled slightly darker. This cover is used when working

directly on tracing paper, thus eliminating much of the measuring with a rule. This paper can be washed with a damp cloth without damaging the surface. Another advantage is the ability to use drafting tape and remove it without damage to the board cover.

Movies and Film Strips

The number of movies and film strips for drafting are quite limited. There are a few correlated to the various textbooks on drafting. Coronet Films, a large distributor of educational films, offers only one film for mechanical drawing.

Opaque Projectors

Quite frequently the drafting instructor has information from magazines, written or drawn material that he wishes to present to the entire group of students at the same time. The opaque projector will work quite satisfactorily in such instances. Projectors are also available for the translucent materials, but they require considerably more preparation by the instructor.

Using Colors to Teach Drafting

In the April, 1956 issue of Industrial Arts and Vocational Education magazine, Scott Williamson discusses a method of using color to teach the understanding of the relationship of views. This technique consists of developing a series of charts, usually on pull down window blinds, to show the relationship of views in Orthographic, Isometric and Oblique projection. For the beginner, the three kinds of projection can be placed on the same chart, with the corresponding views of each colored the same color. On subsequent charts, only one type of projection is placed on the chart. When working with Orthographic projection

the student is shown the chart with Isometric projection. The student draws the corresponding views in orthographic and colors the views to match those on the chart from which the work is being done. When working with isometric projection, the reverse procedure is followed.

The Flannel Board

Another visual means of showing the relationship of views is the flannel board. This board works in much the same way as the charts except that one board will serve for all of the demonstrations. The flannel board is usually constructed of hardboard or plywood placed in a picture frame. The surface of the board, as the name implies, is covered with flannel. The objects to be displayed are cut from contrasting colors of flannel. When the pieces of flannel are placed against the flannel of the board the nap of the material causes them to stick together.

Isometric Blackboard

When doing free hand sketching or drawing on the chalk board it is exceedingly difficult to draw all lines exactly the proper length and at exactly the correct angle. One method of solving this problem is draw equally spaced isometric lines to the right and to the left from the vertical axes. These lines will cover the entire surface of the board. All lines are scribed permanently into the board with an awl. When the lines are erased the scribed lines will be barely visible to the user of the board. No attempt is made to conceal the fact guide lines are being used even though they are not visible from the work stations. This idea was developed by the author and used in the high school drafting room in Mt. Carmel, Illinois. The results obtained when using this board were very satisfactory.

Ruled Clear Plastic

The use of graph or isometric paper is objectional to many people because of all the lines left on the finished drawing. One method of eliminating these lines on the finished work is to use a piece of one sixteenth inch plexiglass and rule it in the same manner as the chalk board in the previous discussion. Instead of scribing the lines with an awl, they are drawn on the plexiglass with a pen. The Rapidagraph pen will work better for this drawing than a conventional ruling pen. There is no tooth to the surface of the plexiglass and caution must be taken to prevent runs and slipping. Grids for laying out one eighth inch graph lines can be accomplished in much the same manner as for isometric lines. The ruled plastic works well with tracing papers; if it is to be used for opaque paper it will probably be necessary to place the work over a cold light copying device.

Cold Light Copying Device

A cold light copying device consists of a box, the interior of which is painted with a highly reflective paint. The bulbs are of the fluorescent type, which emit less heat than the typical incandescent lamp, hence the name cold light. The cold light copying device is available as a manufactured item from distributors of drafting supplies or it can be constructed by the individual teacher. This device is used for copying drawings from opaque paper to other opaque paper, or it can be used as a testing device to check the accuracy of drawings against a master copy. The cold light copying device is also useful as a display for slides and transparencies.

Perspective Drawing Board

When doing design work for prospective customers in custom cabinet work it is frequently necessary to offer a visual picture of the object being planned. The customer has not purchased the proposed merchandise so no great amount of time can go into the presentation drawings. However, the better the visual picture presented the more likelihood of selling the prospective customer the merchandise. The perspective drawing board was designed to enable the user to quickly and accurately describe the proposals being presented. The idea was adapted by the author from information published in Kitchen Business Magazine. The drawing board was made from three fourths inch Novaply and covered with a light green Formica. Near the center of the board a horizontal line was drawn across the board. Vanishing points were established to the right and left edges of the board. Using a floor plan for a corner kitchen cabinet arrangement with a scale of one half inch equals one foot, the floor plan was placed above the established eye level line at a thirty degree angle to the right. A station point was established as though the perspective were to be drawn on paper. Instead of the cabinet being drawn with doors and drawers, the master plan placed on the drawing board was drawn with vertical divisions spaced at one foot intervals for a length of fifteen feet in each direction. Lines were drawn on the floor representing one foot squares. Seven feet above the floor lines were drawn to represent the placement of the soffit. After the mechanical perspective was completed in pencil on the drawing board, a straightedge and awl were used to scribe the lines permanently into the Formica. The lines were then traced with ink to make them visible through tracing paper.

Chalkboard Drafting Machine

The chalkboard drafting machine can be a rather crude homemade piece of equipment or a very elaborate one such as the Paragon chalkboard drafting machine manufactured by Keuffel and Esser Company.

The Auto-Flow Chalkboard Drafting Machine is a remarkably versatile aid to visual teaching and student comprehension. Combining the functions of T-square, straightedge, triangle, scale and protractor, it is recommended for classes in mathematics, science, industrial arts and other technical subjects where visual classroom presentations are required. Students see more clearly - angles and lengths are exact - details clearly observed. Diagrams rendered with the Auto-Flow are sharp and precise encouraging neat working habits.¹

Chalkboard drafting machines are available in most states under the National Defense Education Act.

¹"Paragon Auto-Flow Chalkboard Drafting Machine," Keuffel and Esser Company, (1960) Literature.

Summary

In present industrial society, time seems to be one of the most valuable assets. The emphasis is placed upon speed and production. This increase in production must be accomplished without a loss of the qualities that are necessary for the completion of working drawings that adequately describe the objects to be manufactured or constructed. In an industrial society time is given a monetary value and industrial establishments use every means available to increase the productivity of their employees. When a device or idea is developed to make the job easier, better, or quicker, it is adopted. New developments are not always accepted enthusiastically by draftsmen in industry because of their reluctance to change.

The teachers of drafting have been even more reluctant to change than draftsmen in industry. Some teachers have made an attempt, on their own initiative, to modernize the teaching of drafting in their local situations.

The teaching of drafting should:

1. Be aware of, and willing to use, new facilities that are being incorporated into the drafting room.
2. Be aware of, and willing to use, new time and labor saving furniture that is being developed.
3. Be aware of, and willing to use, new tools as they are developed.
4. Be aware of modern materials that are being developed, and be willing to use them.

5. Use any device that will make drafting easier for the student to understand, or easier to accomplish.

APPENDIX

Survey of Industries by Herbert W. Yankee

No.	Pencils	Drawing Devices	Scales	Compasses	Fasteners	Lettering styles	Importance of Lettering	Height of Lettering	Use of Mech. Lettering Sets	Inking	Papers	Reproduction Process	Background
1	Automatic With Slip Chuck	Wood Pencil	Triangular Engineers	Adjustable Leg	Teaks	Lower Case-Vertical	Slight Amount	1/8 inch	Yes	Never	Cloth	Blue-Print Process	Majority College Grad.
2	Drafting Machine	Straight Edge	Flat With Two Bevels-one side	Center base	Teaks	Lower Case-Vertical	Moderate Amount	1/8 inch	No	Seldom	Tracing Paper	Galid Process	Majority High School Grad.
3	T-Square	T-Square	Flat With Four Bevels	Steel	Teaks	Gothic Cap-Vertical	Great Amount	1/8 inch	Yes	Often	Detail Paper	Photostat Process	
4	Triangular Engineers	Triangular Engineers	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Gothic Cap-Vertical	Slight Amount	1/8 inch	No	Never	Detail Paper	Galid Process	
5	Flat With Two Bevels-one side	Straight Edge	Flat With Four Bevels	Center base	Teaks	Lower Case-Vertical	Moderate Amount	1/8 inch	Yes	Seldom	Tracing Paper	Galid Process	
6	Flat With Four Bevels	T-Square	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Gothic Cap-Vertical	Great Amount	1/8 inch	No	Often	Detail Paper	Photostat Process	
7	Flat With Two Bevels-one side	Drafting Machine	Flat With Four Bevels	Center base	Teaks	Lower Case-Vertical	Slight Amount	1/8 inch	Yes	Never	Cloth	Blue-Print Process	
8	Flat With Four Bevels	T-Square	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Gothic Cap-Vertical	Moderate Amount	1/8 inch	No	Seldom	Tracing Paper	Galid Process	
9	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Lower Case-Vertical	Great Amount	1/8 inch	Yes	Often	Detail Paper	Photostat Process	
10	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Slight Amount	1/8 inch	No	Never	Cloth	Blue-Print Process	
11	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Moderate Amount	1/8 inch	Yes	Seldom	Tracing Paper	Galid Process	
12	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Great Amount	1/8 inch	No	Often	Detail Paper	Photostat Process	
13	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Slight Amount	1/8 inch	Yes	Never	Cloth	Blue-Print Process	
14	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Moderate Amount	1/8 inch	No	Seldom	Tracing Paper	Galid Process	
15	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Great Amount	1/8 inch	Yes	Often	Detail Paper	Photostat Process	
16	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Slight Amount	1/8 inch	No	Never	Cloth	Blue-Print Process	
17	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Moderate Amount	1/8 inch	Yes	Seldom	Tracing Paper	Galid Process	
18	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Great Amount	1/8 inch	No	Often	Detail Paper	Photostat Process	
19	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Slight Amount	1/8 inch	Yes	Never	Cloth	Blue-Print Process	
20	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Moderate Amount	1/8 inch	No	Seldom	Tracing Paper	Galid Process	
21	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Great Amount	1/8 inch	Yes	Often	Detail Paper	Photostat Process	
22	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Slight Amount	1/8 inch	No	Never	Cloth	Blue-Print Process	
23	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Moderate Amount	1/8 inch	Yes	Seldom	Tracing Paper	Galid Process	
24	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Great Amount	1/8 inch	No	Often	Detail Paper	Photostat Process	
25	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Slight Amount	1/8 inch	Yes	Never	Cloth	Blue-Print Process	
26	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Moderate Amount	1/8 inch	No	Seldom	Tracing Paper	Galid Process	
27	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Great Amount	1/8 inch	Yes	Often	Detail Paper	Photostat Process	
28	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Slight Amount	1/8 inch	No	Never	Cloth	Blue-Print Process	
29	Adjustable Leg	T-Square	Flat With Four Bevels	Center base	Teaks	Gothic Cap-Vertical	Moderate Amount	1/8 inch	Yes	Seldom	Tracing Paper	Galid Process	
30	Center base	Drafting Machine	Flat With Two Bevels-one side	Adjustable Leg	Teaks	Lower Case-Vertical	Great Amount	1/8 inch	No	Often	Detail Paper	Photostat Process	

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