AN ABSTRACT OF THE THESIS OF

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for Teaching Difficult Areas in Drafting---------

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During years of experience in teaching drafting to high school students at Richmond, California, and to terminal students in the junior college at Stockton, California, the conviction has grown in the writer's mind that teaching methods commonly employed in drafting classes needed revision. This conviction resulted from observations of the learning difficulties of drafting students. These difficulties were aggravated by the heterogeneous nature of the classes at both institutions. Less than ten per cent of the students in the high school drafting classes planned to continue their work in college. A few took drafting because it was required as a part of their shop courses; some took drafting as a part of an art course; others took drafting as a vocational subject; and the remainder were without definite objectives. In the junior college the total number of drafting students is smaller than in the high school, yet the distribution according to objectives remained approximately the same. There was an increase in those having a direct or semi-vocational interest in drafting as well as in the total number of art students.

Drafting students at both institutions were relatively unselected and ranged across the whole scale of ability and interest. The problem then became that of setting up a course that could be grasped by the weakest drafting students and yet which would interest and satisfy the superior students.

Drafting training consists of the presentation of informations that relate to the selection and placing of views of commonly drawn objects, such as machines, houses, or furniture; it consists of skills and techniques necessary to the efficient construction of these views; and acquaintance
with the informations and practices used in drafting.

The writer's viewpoint went through a transition, changing from that of the professional draftsman, interested in techniques and production, to a recognition of the learning problems and difficulties of the adolescent high school boy and girl and the older junior college student. This new point of view forced recognition of a need to develop methods of teaching drafting informations, skills, and techniques. The lecture-demonstration method was tried for teaching this information to both large and small groups; individual demonstrations were tried; an extensive writing program was carried on; textbooks were widely used; but none of these methods produced the desired efficient method of teaching.

An analysis was made of learning units in drafting to find the areas where ordinary methods fail. The results of this analysis was the recognition of areas that needed treatment. Different methods were tried to find those most satisfactory for use in presenting the information in these areas. Some of these methods were, the preparation of special blackboard demonstration equipment; the drawing of wall charts; and the devising of simplified demonstrations. When a motion picture camera and projector became available at Richmond, a series of teaching films were taken as a solution to this problem.

This study is centered upon the development of the teaching motion picture and its adaptation to teaching situations in the classroom. It covers the development of equipment and methods for taking the teaching film and the animated film. It describes the experimenting which was done to develop equipment and methods for using the films in the classroom, which involved moving classes to a special projection room, as well as in presenting the film in the drafting classroom. The projection tunnel was developed and tested for use in the lighted classroom. Various materials and surfaces were tried for viewing the projected pictures.

A technique was developed for presenting new topics by means of films. Methods were developed for individual demonstration. A device was constructed to use films in the classroom to show techniques and processes which needed repetition. The film editor was pressed into service as an individual teaching device for students to use at their desks. Processes for remedial instruction were developed. The use of the motion picture camera was also brought out in the production of films as part of the teaching process.
As a result of the study, it seems obvious that certain needs in the drafting field should be met. A re-analysis and simplification of drafting for the non-college and general education student is needed. Many more teaching films are needed in drafting. There is need for simple and inexpensive projection equipment. Film viewers must be re-designed to adapt them to instructional use. Textbooks, lesson sheets, and work guides, correlated with the teaching film, are needed. A supply of the films should be available through film libraries. Remedial teaching, by use of the teaching film, would be the basis for an excellent future study.
THE DEVELOPMENT AND USE OF MOTION PICTURES FOR TEACHING DIFFICULT AREAS IN DRAFTING

by

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THE DEVELOPMENT AND USE OF MOTION PICTURES
FOR TEACHING DIFFICULT AREAS IN
DRAFTING

CHAPTER I

INTRODUCTION

The mechanical drawing teacher in the secondary school is faced with a number of problems that demand attention. He is faced with a student population that falls into groups with a wide range of abilities and with widely varying degrees of interest, due partly to the present tendency to demand that all students continue in school until 16 years of age or longer.

He formerly dealt with a selected group of students that had relatively little difficulty in understanding and performing the operations and processes involved in drafting. He now is faced with students who, both from lack of interest and lack of background, are slower to grasp meanings and implications from lecture, demonstration, and discussion.

Weaknesses inherent in these commonly used teaching devices all point toward the need for a new method that will be more effective in teaching these students. This need is particularly apparent in certain areas of drafting which, by the nature of their content, are unusually difficult to teach. It is necessary in the search for this new
method to use in teaching these difficult areas to keep in mind the following points:

1. A method must be found or devised that will present the principles and practices of drafting in a manner more vivid and more interest-arousing than was possible by older methods.

2. A method of presentation must be selected which is understandable by students of widely varying interests and background.

3. A method must be selected which will show clearly and quickly the details of an instrument, a technique, or a process.

4. A method must be selected which will fit the large numbers of students who have other than a college objective.

It is believed that time-tested teaching methods can be improved. It is felt that more effective teaching aids can be devised.

As the result of long contact with students who had no intention of going to college and yet who felt the need for training in drafting, it became apparent that methods of presenting drafting knowledge needed simplification as well as the addition of some interest building treatment.

Further, there was evident need in this subject which depends so much on skill, for a rapid and efficient method of presentation that would increase learning efficiency so as to allow more time to make drawings.

Efficiency of learning demands that the student
grasp quickly, completely, and vividly the information being presented so that he can put it into immediate use.

This thought is expressed by Horner (12:4-5)*, who says:

The aims of every progressive teacher should be to plan and to present his work so that the students may master the subject (technique or information) with facility and with economy of time. Among the methods to be employed should be listed everything that increases the appeal and clarifies the subject-matter, for such methods will promote efficiency and give more time for other endeavors.

The instructor who has experimented with visual aids in his shop program has no doubt concluded that this is one of the easiest and surest methods of promoting natural learning. In visual instruction he probably has found some of the most efficient instruments wherewith to insure vividness and concreteness of concepts formed by the students.

Statement of the Problem

In this study is presented the method used in developing and fitting the teaching motion picture for use in drafting classes as a solution to some of these teaching problems. It is the purpose of this study to describe the construction and the development of a group of films specially designed to aid teachers in presenting instruction in certain areas of drafting which are

* The first number refers to the correspondingly numbered item in the bibliography. The second number refers to the page of the reference.
unusually difficult for the average student group to grasp when presented by methods ordinarily employed.

The Scope of the Study

The time and expense involved and the availability of material limited the study to the development of equipment, to the taking of the teaching film, and to a consideration of their uses in the classroom under teaching conditions. The limitation of time can be appreciated better when one realizes that approximately two hours of time is needed to photograph an animated sequence that runs through the projector in ten seconds.

Procedure

While the writer had long felt the need for better methods of presentation of drafting information and skills, yet the use of films as the best available solution to the problem became possible only after a number of years of experimentation.

The experimentation proceeded along these lines; first, an extensive use of the lecture method including note taking by the students; second, the compilation of the material included in the notes into instruction sheets with a resulting transfer of lecture time to drafting practice; third, a parallel testing and development of devices to make more effective presentation by lecture,
coupled with testing of the small-group demonstration technique; fourth, and finally, the development of the teaching film.

The procedure while developing the film may be divided as follows: first, the parts of the drafting course which proved hard to present to the class by lecture, demonstration, or in lesson sheet form were isolated; second, criteria were set up for the selection of the type of film that should be used in presenting this information; third, both equipment and techniques were developed for taking the pictures; fourth, methods of using the films in the classroom had to be developed; and fifth, projection equipment had to be devised and tested.

The teaching methods and the teaching films described in this study have been worked out by the writer in teaching drafting to high school students over a period of eleven years at Richmond, California; in teaching terminal students in the junior college at Stockton, California for three years; and in teaching graduate students and teachers-in-service during summer sessions at Oregon State College, Corvallis for four years.
CHAPTER II

REVIEW OF RELATED STUDIES

During the time covered by this study, a continuous search has been made for published material that would aid in the development of the teaching film and of the technique for its use in the classroom. Little material is available in suitable form to be used by the individual teacher in preparing his teaching films. Articles published in various popular magazines describing the animated motion picture produced in Hollywood and by other technical studios offered little help on account of the expensive type of equipment as well as by the nature of the films themselves.

Certain related studies are reviewed briefly in the following paragraphs:


In this study the author has discussed the use of combined visual aids and unit instruction sheets for the teaching of a course in auto mechanics. His contribution is that of a careful analysis of the field and the setting up of unit lessons around this analysis. Other than illustrating his instruction units with excellent
photographs and drawings little use is made of visual aids.


The validity and implications pertaining to visual materials are covered in this thesis. Also this writer collects the types of different teaching aids useful in the classroom and discusses their application and limitation. His discussion of the important considerations in a satisfactory teaching film touches on its use in the classroom. He shows an excellent group of applications of the visual aid to specific teaching situations.


His review of the difficulties preventing wider application in the classroom of visual aids is excellent, as is his discussion of benefits to be derived from the use of the aids. His suggestion of a plan for integrating films into a course of study may be used as a guide to the teacher organizing a course in drafting. Valuable, also, are his suggestions on the field trip, the glass slide, graphs, maps and exhibits.

This is an experimental study in which the author attempts to determine: (1) the feasibility of using motion pictures as a means of instruction in introductory mechanical drawing; (2) whether such an instruction unit would be more efficient than demonstrations by the instructor; (3) whether such a unit would be more economical in time than conventional methods; and (4) whether similar units would be advisable in the introduction of subsequent phases of mechanical drawing.

Brown, T. C.; and Drafting Room Practices, Engineering Experiment Station, North Carolina State College of Agriculture and Engineering, Bulletin #21, 1940.

This report, which covers only the State of North Carolina, indicates that there is relatively little interest among the colleges in the use of visual aids for teaching drafting. Only six are reported as using motion pictures, while nine use glass slides. Of the 84 institutions not using motion pictures some indicate an interest and desire to try them. A few institutions have interested themselves in the use of the motion picture to teach lettering, with very encouraging results. Those institutions which have
tried both the sound and silent motion picture report excellent results from their work.
CHAPTER III

BACKGROUND OF THE STUDY

How the Problem Came to be Recognized

In 1924, while a student at Oregon State College, the writer discovered that mechanical drawing teaching was following a set pattern which had existed for many years. The same pattern was used in the high school where he had learned the fundamentals of drafting, and in the engineering courses in college. The problems were fitted to the different age groups, but the general pattern of topic-outline was the same. This pattern followed a logical presentation of the material but was fitted poorly to the needs of the learner. The similarity of material and the continuation of a topic-type of course presented a challenge to devise a better teaching method. Perhaps this challenge, coupled with an interest in drafting, influenced the writer to transfer to industrial arts and to prepare for entrance into the teaching field.

The search for a better teaching procedure led first to the preparation of teaching outlines and lessons, which included many detailed methods and handy kinks used by draftsmen, but not commonly found in texts or in the classroom where mechanical drawing was taught. These were methods and hints that students needed to know so that they
could learn to draw more easily and more rapidly. In looking back over this period, it reflects a review of drafting as seen through the eyes of a teacher, where previously the work has been thought of from the point of view first of a learner, then as a professional draftsman. While doing job drafting, as well as during employment in different commercial drafting rooms, it seemed that the academic approach used in teaching drawing left much to be desired. The attitude of workmanship, as seen from the draftsman's point of view, was largely absent. Drawing had been reduced to meaningless exercises that had little touch with reality.

The first teaching position held by the writer showed the difference in method and in handling between the commercial draftsman and the student draftsman. The commercial draftsman is interested in production. His job is to turn out rapidly and efficiently drawings that fit definite situations. He is expected to be well qualified in tool techniques, projection theory, and in all of the trade kinks that make up the working tools and methods of an experienced workman. But little of this type of information can be used by the learner.

Instead of trying to give trade methods and skills to a beginner, the problem must be approached from the instructional point of view. Any work the student does
must be chosen with his learning problems in mind. The sequence of informations and skills must fit the learning process rather than the production process. The development of skill must be slow and must be capable of adjustment to the learner's needs.

This principle is clearly expressed by Payne. His words adequately describe the transition faced by the writer at Richmond. He outlines succinctly the process of analyzing and writing lessons and the accompanying search for effective teaching methods. Payne says (14:3):

The trade workers who aspire to become efficient in the field of teaching must be prepared to learn a new vocation, that of teaching their particular trade. They must learn the psychology of the students, the psychology and pedagogy of the teaching-learning process. They must learn that, as there are very definite techniques of handling tools, materials, and processes, so there are equally definite techniques of teaching.

They must learn to analyze their vocations, organize, and classify the material derived from these analyses into courses of study, into lessons, lesson plans, job sheets, project outlines, instruction sheets, etc.

Teaching at Richmond offered many peculiar opportunities. From 12 per cent to 16 per cent of the total student body of the school enrolled in the drafting classes. This percentage increased as the school population increased. (It was approximately 800 in 1927 and 1600 in 1937) With few exceptions drawing was taken as a tenth
year subject. A few eleventh and twelfth year students were in the drawing classes as a result of late changes in major courses or because they had continued into advanced drafting. These students represented a cross-section of the school population. They represented many objectives, as listed in the courses they were taking; they represented many ability levels; and they came from many diversified home situations.

The industrial arts objective was foremost. The large majority of these boys were in the drawing class because they liked manipulative activities. In each hundred students there would be found from fifty to sixty students of this type. These boys took one year of drafting.

A smaller group of students prepared for drafting as a vocation. They generally took two years of drafting. There were seldom more than four or five of these boys in every hundred students. About a like number presented drafting as a required subject for college entrance in such courses as engineering, architecture and art. They were allowed only one year (two semesters of twenty weeks) in which to complete their drafting training. Classes were fifty minutes long and were held daily.

A considerable proportion of those taking the subject were pursuing it as an elective. They selected
mechanical drawing, shop work, or applied science in an attempt to salvage their interest and direct it into some useful line. Many took drawing because they wanted credit. Richmond, within a few minutes drive of Oakland, Berkeley, and San Francisco, is definitely within the big city atmosphere. Its location had considerable effect upon the student attitude.

The Teaching Situation at Richmond

The Student's Family and Educational Background. Students taking the mechanical drawing courses at Richmond were drawn from American and foreign families. There were many whose families were from the South European areas; there was a small number of Japanese and Chinese parentage; and there were a few Negroes. The Italians were in the majority. Parents of these children were engaged in some form of mechanical work in the Standard Oil Refinery, or the Rheem Manufacturing Company, or in other industries located in Richmond and nearby towns. A smaller number of students came from families employed in business or in the professions. Some came from the surrounding countryside where agriculture and market gardening was done.

There was a noticeable difference in educational background between children growing up in homes where the parents had had little training and those who were well
trained. Many of the Japanese and South European children were excellent workers, being both industrious and careful. The most outstanding students were from homes where the father or mother had had training beyond grade school or were engaged in professions or businesses that formed a background on which the child could build. Several examples of outstanding students in this group may be cited: One was a boy whose father was the art director in the local art tile manufacturing company; another was a girl whose father managed a technical porcelain factory; and the third was a girl whose father was the manager of the local branch of a large furniture store, part of a chain which extended over Central California.

**Why They Were Taking Drawing.** Out of approximately 250 students a day taking mechanical drawing from two separate teachers, a goodly proportion were taking the subject as part of a course that prescribed drawing as a required subject. Another group took drawing as an optional subject, and a relatively small group took drawing as a definite trade subject.

These students were further divided into two groups - those coming from the junior high school where they had had a so-called "finding course" in drawing and those who had had no previous training. It can readily be
seen from this description that the teaching situation at Richmond was that of the average large high school where mechanical drawing is offered. A cross-section of the students would show a few definitely opposed to work of any kind; a number of students without feeling one way or another toward drafting; a number of students taking drafting because their course demanded it; a group taking drawing because it was included in their shop courses; a small number taking drawing to meet college entrance requirements; and another small group taking drafting as a vocational subject.

The resulting heterogenous group was one which required widely different types of handling. With from five to seven classes a day, a carefully organized activity program was necessary to keep the students busy at worthwhile activities. The wide variation in intelligence, interest, and ability in drafting also raised many teaching problems.

The Ability Level of Students Studied

At Richmond. With a large proportion of the drafting students of average ability and with non-college aims, teaching problems differed widely from those encountered in classes of college ability. Such a situation often results in a discipline problem among the low ability group. Among
them are many who think slowly and who fail to understand explanations from reading or from diagrams in texts. These boys are literal and concrete in their thinking. Little can be done for them in the abstract. These students lack the motivation of the better equipped students who plan to enter college and who have the mental equipment to do so. Such students must have their work planned so that there is some external motivation. There probably are many reasons for this attitude, one of which has been well expressed by Dorris (8:17), who might have been describing these particular students when she said,

"Children, largely because of their limited experience and lack of knowledge as a basis for understanding and appreciation, are not interested in the abstract . . . They are more apt to be interested in things, objects and people."

These students, in general, have a very different life objective than the traditional high school student who was being prepared for college entrance and for a place of leadership. They are those described as "the other 85 percent". They are those who will be tradesmen, or small businessmen, or who will be laborers.

At Stockton. Among the terminal students at the junior college we find the same elements in the student group as were encountered at Richmond. Here, first and second year
junior college students taking terminal courses were enrolled in semi-vocational drafting; art majors were taking drafting as a service course in which to learn instrumentation and perspective; and a few were vocational students.

In Stockton there is a variation in ability and interest equal to that found in the high school group. This is a more selected group, although a small percentage come to the terminal classes without high school training.

Teaching Problems and Methods

Skills and Techniques. As the drafting teacher analyzes his subject and faces his teaching problems, he finds among them certain factors which may roughly be divided into two parts; one, the teaching of drafting skills; and the other, the teaching of drafting informations. We may consider them in this order. Drafting skills are generally referred to in textbooks as Instrumentation, which includes such things as the methods of using the drawing tools and instruments. Here emphasis is placed on learning certain techniques that are inherent in the design of the tool or instrument, and which depend on the work that is done with them.

It is of major importance for the student to learn these basic techniques thoroughly and at once. The problem of the instructor is to show effectively the
setting of the tool or instrument, any necessary adjustments to it, and the details of the technique of its use.

These skills and techniques are taught by demonstrations, lectures, and individual assistance. Here is probably the weakest part of the teaching process.

Information, Principle, Method. Included in the list of information topics are problems of presenting clearly to the student the steps in a process and in assisting him to learn its basic principles. This occurs first in the study of simple orthographic projection and later as projection is used in special cases, such as auxiliary projection, sectioning, or in pictorial projections.

These information topics have been taught by lesson sheets, textbooks, lectures, demonstrations, or by combinations of these methods. These teaching methods are more successful for presenting information than are the methods used to teach the skills. But they, too, can be improved.

Practice Time - Experience. Drafting must be taught so the student has an opportunity for much practice. He must be able to practice a method or a principle that he has learned enough times to master it before he goes on to another. This need imposes in the instructor the necessity for a method of presentation that is fast and efficient
and which will take but little time from his work on the drawing board.

Dorris (8:3) expresses this idea in these words:

Much is said in recent times about efficiency in work and economy of time. These two factors are just as necessary and important in the educational field as in industrial and commercial life. Hence there is need of finding as many effective service agencies as possible to increase the efficiency of the teaching process. Among these agencies is to be listed whatever increases the appeal and clarifies the matter to be mastered, for such an agency aids economy and thus frees time for other efforts.

The importance of time to the high school student can be realized when we find that he often takes such a poorly presented course that he can complete only thirty to forty small drawings per semester. Small wonder that Dorris (8:21) repeats:

"Conservation of time has been emphasized in preceding pages as being as necessary in educational procedure as in the management of any industry or business. The child's time is precious. . . ."

Teachers must find a demonstration technique that will be direct, vivid and obvious, and which will require a minimum of the student's time to master.

The Weakness of Commonly Used Teaching Methods

The Class Demonstration. When teaching mechanical drawing to relatively large class groups by the standard lecture-
demonstration method, a demonstration technique must be used that will allow each student in the class to see clearly and to understand easily the explanation of the method, technique, or process which is described in the lecture. Umstattd (16:300) expresses the value of the blackboard as a visual teaching aid in these words:

The teacher should use the blackboard frequently as he explains new points to the group. . . . drawings not only clarify the points; they remain on the board for a time and by their repeated impressions aid retention as well. A good blackboard technique will add to the effectiveness of any teacher. It is a skill which should be acquired by all.

Chalk drawings on the blackboard are commonly used to enlarge the tool or show the process so that all the class can see it. For drafting processes such as orthographic projection, for geometric constructions and for step-by-step processes, the use of the board demonstration is excellent and permits a clear explanation of a sequence. The necessary drawing can be made large enough to be seen easily from any part of the classroom by all members of the class listening to the lecture.

This method of class demonstration is used where a smooth flow of steps can be used to describe the details of the process. A board demonstration is generally successful in describing the basic principles involved in projection in either the first angle or the third angle. It can also be used to discuss the shape and proportion of letters. It
could be used equally well in explaining the principle of auxiliary projection or the method of laying out simple patterns for sheet metal drawings.

Board demonstration is excellent for occasional group discussions of the geometric construction processes, steps in the different projection processes, and drawing sheet sizes and layouts. Board demonstration is especially effective when the student follows the explanation on the board by doing the same steps on a drawing at his desk. This permits the student to ask for answers to questions which may occur to him as he attempts to duplicate the drawing being made on the blackboard. But an attempt to show by a blackboard drawing the condition of the nibs of a ruling pen, or the setting and adjustment of the needle-point of a compass is seldom successful.

There are several reasons for the failure of blackboard drawings for demonstrations of this later type. One reason for its lack of success is that few instructors are good enough artists to be able to make a convincing sketch of the pen or the compass. Complete transfer of information under these conditions can result only after long explanation at the board, followed by extended individual instruction, a method that is very inefficient. There is little carry-over from the average or poorly-made sketch on the blackboard, by means of which the instructor
attempts to show the use of the pen or compass, to the same instrument in the student's hands as he attempts to do the work on his drawing board.

Success in transfer of training is greater when a rapidly but accurately-made sketch is used to illustrate the principle or the application coupled with an effective and flowing lecture, or patter that parallels and describes the work being demonstrated. Few teachers are able to do this effectively. In this respect, the board demonstration fails.

Teaching by lecture has a serious disadvantage inherent in any form of discussion. Success in verbal transfer depends, according to Weber (17:25), on a commonness of experience. He says,

"Verbal transfer is a marvelous economy in many ways, but only when both parties to the exchange of ideas have a common experience."

This requirement immediately places the beginning and inexperienced student at a serious disadvantage. Few such students have had sufficient experience to gain much of value from a lecture. This difficulty has been heightened further by the use of language that was far too technical for them to understand. Dorris reports (9:25):

"Examination reveals that ... from 50 per cent to 75 per cent of our teaching passes over the heads of
the majority of our pupils because it is too abstract and bookish."

Yet we have long lived under the curse of excessive verbalization in the teaching of drafting. This has been partly due to the selected group of students generally found in secondary schools. They could grasp enough from a verbal explanation to be able to supply the rest out of their own experience on the drafting board. To overcome this disadvantage we must provide such students with an immediate and vivid first impression. To again quote Weber (17:28),

"For the creation of a brand-new idea, the actual experience is the best method of approach. It conveys clearcut images and relation feelings; and it does this in a way which is not only quicker but also more satisfying to the learner."

As we have pointed out, the nature of the drafting tools and instruments makes this impossible by the lecture-demonstration method alone. The adjustment or the setting of the needle point on the bow compass can be demonstrated to only three or four students because the needle is smaller than one-sixteenth inch in diameter and the adjustments which must be made on it are in proportion to that size. Little success accompanies a verbal explanation of the adjustment. Some method of presenting this
informational unit to both small and large groups is needed, and there are many similar situations in other tool operations or processes of drafting.

Board drawings are often rapidly and poorly drawn since few drafting teachers are excellent artists. Enough relevant detail is omitted from the drawing to reduce seriously the transfer of the idea from the drawing to the student. A drawing, at best, is only a fair substitute for the actual object being studied, as for example, when the discussion centers around the adjustment of the nibs of the ruling pen or the setting of the needle-point on a compass. During this discussion the pen or compass should be used to explain the needed adjustment or setting.

In describing the difficulties inherent in a lecture type of presentation, Hoelscher says (11:168):

One needs only note the difficulty with which adults get and retain the gist of a lecture, to be convinced that the lecture method is wasteful. The listener's mind must travel at the same rate as the lecturer's. To linger after an idea in an attempt to get its full meaning means the loss of the speaker's next point. No matter how slowly the teacher may go or how many times he may repeat, the person who tries to grasp the full significance of what is said will shortly find himself behind.

A further disadvantage of the board demonstration lies in the fact that the teacher is often from thirty to forty feet from some members of the class.
Students sitting in parts of the room distant from the board seldom can hear clearly all of the discussion and often are unable to see all of the process as it is demonstrated. Defective hearing and sight both increase these difficulties. The problem is further complicated by the average high school student's reluctance toward mentioning such personal difficulties to the instructor with a request that he might change his seat to see or hear better. Either of these reasons can cause partial or total loss to such students of the information contained in the lecture. At a distance, instruction in details of adjustment of the small instruments and drawing tools is a total loss.

Class demonstrations, with the whole class grouped around the instructor, offer discipline problems caused by crowding. Often only a few students can see and profit by such a demonstration. Small groups must be used if all are to see the details of the demonstration, but the instructor must repeat the demonstration enough times to cover the entire class. This method makes inefficient use of the instructor's time.

Several obvious but relatively ineffective solutions to the weaknesses of the board demonstration present themselves. Large and complete drawings are often made on the blackboard with large drafting instruments made
especially for use at the blackboard. Some drafting teachers are very effective in making such drawings, which are excellent examples of draftsmanship and make fine displays. But these display drawings lack certain important requisites if they are to be used as a teaching device. A drawing used for demonstration purposes must be made during the discussion. The student should see it grow and should hear the accompanying explanation as it is being drawn. His problem is to know how the parts of the drawing are made, and the proper sequence to follow in making them. The display drawing which requires so much time and effort to execute that the draftsman feels it should remain on the board, is not a demonstration except to those who saw it in the making. It has been said that a display which remains before a group for over a week is ineffective. Such drawings often are on the board all semester, but fail of usefulness to all except a few who saw them created. Students need frequent demonstrations and often the demonstration must be repeated.

By making each demonstration drawing on a large sheet of paper or on cardboard, many drawings can be made and can be available when needed. They may be made large enough for use during class demonstrations. Yet the advantages of size and availability are offset because the
student cannot watch the drawing process. Unless he sees a drawing made, line by line, he will not appreciate and understand the detailed steps involved in its construction. Few students have the ability to analyze the detailed steps and processes of any but the simpler drawings during their first year of drafting. The lack of motion and of sequence in a completed display drawing are extremely difficult to offset verbally, even when the parts of the drawing are pointed out during the explanation.

An ideal teaching situation occurs in the drafting room when constant teacher-student contact is possible. The student then can watch the instructor as he performs the various tool and instrument operations and he can watch the instructor follow the steps of each new process through to the completion of the job. This method is undoubtedly ideal as far as learning is concerned. But there are many reasons why it is impractical. One reason is the size of classes. It is obviously impossible to make many teacher-student contacts in a 50 minute class period with classes of from 20 to 40 students. An even division of the available time among the members of the class would only allow each student two or three minutes each day with the instructor. This situation seldom need exist in a class equipped with suitable textbook or other lesson materials. Few of the students need constant individual
attention. Most of them can do their work alone and require occasional assistance after they have seen the demonstration.

Each student should have several contacts with the instructor each week to build good working attitudes and good working methods. These may be checked easily with the student during a personal discussion or during an occasional demonstration on his board. He will learn more from observing the way the instructor does a piece of work than he will in many pages of reading.

This personal assistance is most effective if it reaches the student when he needs it. He should be able to see how to manipulate a tool or how to make a measurement at the time he is working on the problem or when he is in difficulty. One of the serious weaknesses of the lecture method of presenting information is that the lecture must be given at the time best suited to the convenience of the teacher and to fit the average needs of the entire class. It involves a questionable carryover from the time of the lecture to the time when the student needs the information as he works on his drawing. The ideal teaching device to replace the lecture would be one that the student can use at the time he needs it so he can avoid long waits for personal help from the instructor or for a class lecture which will be so quickly forgotten. To be
most effective this ideal device should supplement the personal contact with the instructor, yet it must show the student the smooth, well coordinated motion of the technique that the instructor would do by demonstration, if he could be available at the time.

Let us summarize these needs and requirements of a satisfactory demonstration. The following items may be listed as definite needs by the teacher of drafting to assist him in giving to each student in his class during the demonstration complete, detailed, and clear information:

The demonstration must show the method to all of the students in the class at the same time in such a way that each student can see clearly its details from his seat in any part of the classroom.

The demonstration must be made by a type of teaching device that overcomes minor optical deficiencies of individual students.

The demonstration must have a means of enlarging the details of a small instrument or part to show the details of a technique so that all students in the class can see it clearly.

The demonstration must be a type of teaching aid that can be used by the teacher with a meager background of training.

The demonstration must be a personalized aid that shows the individual student that the instruction is something that he can do.
The Motion Picture Offers a Solution

The teaching film furnished an ideal solution to these different problems which were faced at Richmond and at Stockton. The low I.Q. student who grasps little from a textbook and who learns but little from abstract description learns with surprising rapidity from watching a filmed process or technique. Hundreds of words are required to explain what can be shown to him in a few minutes by a motion picture. The uninterested student is assisted to learn because of the greater interest in the film type of presentation.

Information presented by the motion picture is acquired more rapidly and is retained much longer than when the same information is presented by a reading process, by a listening process, or by a combination of both.

Certain desirable factors stand out in the learning process conducted by the use of the motion picture as a teaching aid. The motion picture produces a novel and vivid first impression, coupled with actual experience because the complete detail can be shown in a vivid and realistic manner.

The motion picture combines definiteness, complete detail, and a smooth flow of motion from step to step, visible to all students within the classroom. The teaching film gives an accurate and complete description, either
when shown to single students or to groups of students. This method shows clearly, completely, and accurately the multitude of small adjustments, processes, and techniques involved in the learning processes of mechanical drawing. Details may be enlarged or subdued as the case may require.

The solution of this problem through the development of the teaching film included the analysis of teaching material in the process of preparing the script, the selection of subjects to film, as well as the application of the teaching film in the classroom.

Equipment Becomes Available at Richmond

The purchase of a Bell-Howell Model 70 DA motion picture camera by the school made possible the taking of these teaching films. With this equipment available, the problem became one of finding ways and means of adapting the camera and the necessary photographic accessories to the problem of actually producing the teaching films. The equipment in the woodshop was used to build a device for taking animated motion pictures. This device was made up of a vertical track on which was mounted a camera attachment and a drawing board. Both were arranged so they could be moved on the track to adjust the distance between them for photographing animated drawings in large or small scale reproduction - for close-ups or general views.
Lights and reflectors were attached to the track and were also adjustable. T-Squares, triangles, drawing sets and other equipment needed for animation were on hand as part of the regular drafting equipment of the school.

Work Done at Stockton

Soon after this equipment was constructed, a change of position occurred and work was resumed the following year at Stockton Junior College. Experiments were made with the teaching type film during which considerable footage was taken of tool techniques. A new animating device was built and installed but the pressure of work involved in the development of new courses for the junior college prevented its extended use.

A considerable amount of experimenting was done here with projection tunnels and in the use of the film in undarkened rooms.

Work on animation was resumed at Corvallis during the summer of 1939 when several films were made. These films have been very popular when shown to the classes in "Methods of Teaching Drafting" and are in demand by these drafting teachers who have taken these courses.
CHAPTER IV

THE DEVELOPMENT OF THE TEACHING FILM

Drafting Instruction Analyzed

Drafting instruction is an unusual problem in some respects. On the one hand it is made up of a group of manipulative experiences that go to make up the different tool and instrument skills. This group of activities has much to do with the interest that drafting holds for the average high school student. With relatively little skill, he can produce a drawing. The result, crude as it may be, is usually pleasing to him. He has had little previous experience in doing the small, accurate, and detailed work necessary to complete a first-class drawing. He knows that with more extended drill and discipline he can learn to do quite respectable work.

On the other hand, drafting, beyond the simple forms of projection which can be learned by the copy-book method, becomes an abstract and analytical problem that requires a good background of principle and some experience to be of use to the student. This is true of many phases of projection and may be characterized by the projection methods used to find lines of intersection, to the understanding of the position of the planes of projection used to find the true shape of auxiliary surfaces, and to
some of the pictorial projections.

Hoelscher (11:20-21) lists three divisions of the economic aim of drafting as knowledge, skill and speed.

Still another problem presents itself in learning the skills of lettering. Lettering, obviously a problem of learning letter shapes as well as the techniques of forming them, under careful analysis becomes a type of motion study combined with recognition of areas enclosed within the letter shape as well as the study of the size relation of these areas. Obviously these analyses cannot be taught as such in high school classes to the type of student who today makes up the average class membership. But teaching lettering, even by simple devices, remains a difficult problem.

Let us pause for a moment to consider the objective toward which a teacher of drafting who meets today's classes must aim. We may, with safety, neglect the objective posed by the college entrance student who must be in the higher intelligence brackets if he is to succeed in the college entrance subjects of high school or later in college. We may also disregard the student with a vocational objective because he must be unusually able in skills, in analytical ability, and in visualization to succeed as a draftsman or a designer. These students present a relatively simple instructional problem because they grasp readily the
explanations of drafting principles and have little trouble in learning the accompanying skills.

We are, however, faced with a group of students in school for other reasons. They are the ones for whom we must set up a general education objective. For them we must stress the vocational objective less and build up instead the appreciational and consumer values of drafting.

This group has less of the keen drive and desire for training than have the college preparatory students. It is made up of students having such a wide variety of interests and abilities that the teaching problem becomes much more difficult than with a more homogenous and selected group. It is this group that presents the teaching problem for which the teaching motion picture offers such a fine solution.

How Difficult Areas Were Determined

Student Response. Direct observation is usable to locate difficult teaching areas in drafting. An alert teacher can easily observe the parts of his course which are not understood by the students in his classes. These areas are most obvious when he uses as a check group those students who consistently experience difficulty with their drawings. They will be unable to do the more difficult types of drawings.
Difficult areas may also be found by examining drawings being made by students who do considerable moving around the room and who visit other students soon after a lecture or demonstration to get help from some friend. It is through these observations that the instructor can find the areas more difficult for students, where greater clarification is needed.

The grading conference is another fruitful source of information about the success of explanations and demonstrations. These conferences, held every two or three weeks, afford enough student-teacher contacts to build up student confidence and to establish a free exchange of ideas to enable him to discuss his problems with the instructor. Checks on the problems returned for correction and on those reported as jobs too difficult to draw were another good index of the areas which needed better methods of presentation.

Drawings of consistently poor quality presented by many students in the class show that the technique was poorly presented. Drawings consistently incorrect show that a principle or process needs further explanation. Both act as guides to areas needing better methods of presentation.

The problems encountered in teaching drafting may be broken down into a few major areas. We may consider
them in the approximate order of their appearance in the learning process made standard by French and Svenson (9).

We may first consider the field of commonly-used drawing tools such as the drawing board, thumbtacks, the T-square, the triangles, erasers, erasing shield, protractors, and the French curve; or the instruments, such as the compass, the bow instruments, the dividers, the ruling pen and the various attachments contained in the drawing set. Workmanship, an objective of drafting courses, demands that the boy be started with instruction which is correct and complete. The first impression is the one remembered longest. It should therefore be given correctly, be vivid, and be presented in such a manner as to fix in mind certain easily-remembered facts.

Thus the first acquaintance with a tool or instrument -- the point at which the learner gets his first information -- is one of the areas difficult to present adequately. It also happens to be one of the neglected areas. Let us list some of the important learning processes that present difficult areas in the group of skills commonly known as instrumentation. Here we find these problems:

How to attach paper to the drawing board.
How to sharpen the pencil.
Where and how to hold the pencil against the T-square to draw straight lines.
The use of triangles.

Measuring methods with the architect's scale.

How to roll the pencil to maintain even line width.

How to make dotted lines.

How to draw lines of different widths.

How to read the scale.

How to make center lines.

Fitting the French curve to a series of points on a curve.

Joining curved lines made with the French curve.

Making corners.

Drawing a curved line tangent to two lines

a. that form a square or 90° corner.

b. that form an acute or an obtuse angle. (the same construction method is used for each)

Sharpening a ruling pen.

Setting the needle point or the shoulder point on a bow compass.

Sharpening the bow compass lead.

Making circular dotted lines or center lines.

How to make arrowheads.

How to use bow compasses to make very small circles.

We may also examine the difficult areas that occur in presenting methods and processes of drafting. As before, these basic skills and information topics must be
clearly and completely presented so the student receives the full information the first time he sees the explanation. These processes and information topics range throughout the whole drafting course. Here are listed typical problems:

How to lay out the border and trim lines for a standard sheet.

Simple orthographic projection.

How to end dotted lines.

The order of placing dimensions on views.

The auxiliary projection process
   a. by the center line method.
   b. by offsets.

Development of flat surfaces.

Intersection principles.

Geometric constructions.

Tangent constructions.

Pictorial projection

The Teaching Film

The teaching films developed during this study fall logically into two main classifications. The first of these will be called the "natural action" film. It is a motion picture taken on safety film of suitable speed and quality to show the persons or the hands and the instruments naturally. The action in the "natural action" film
was taken in normal, continual motion exactly as the job was performed.

This type of filming was used to show the handling of drawing tools and equipment such as the method of attaching paper to the drawing board or how to draw small circles with a bow compass. In all of the films of this type the students carrying on the demonstration, or at least the hands, were visible.

The second classification is the animated motion picture or the animated drawing, in which animation was used to show processes. This type will be explained later.

One of the first natural motion teaching films was taken because there was a need for a better method of demonstrating the use of the French curve. The use of the French curve is one of the tool techniques most dreaded by students in high school drafting classes and one which few students feel competent to handle after attempting the process. Such fears can be avoided by the use of a demonstration that shows clearly the details of the method of using the curve and how to avoid errors commonly made in its use. Such information produces confidence.

An analysis of the technique of using the French curve shows three points of importance, all of which the student must know if he is to be able to draw a satisfactory curve. These points are rather simple and perhaps are so obvious that he misses them during a demonstration. First,
construction lines must be drawn to determine the points through which the curve is to be drawn. See Figure 1. These points are used to locate the direction and the curvature of the line; second, the French curve must be placed so that its edge touches a minimum of three and preferably more of the points determined by the construction lines, while drawing each part of the curve; third, new parts of the curve should be drawn as a continuation of the line instead of joining a new curve to a part already completed.

To the average student in a drafting class, the use of the French curve is one of a small group of techniques that present unusual difficulties in learning. It became apparent, after analyzing the operations involved in the use of the French curve that this difficulty occurred because the student had not seen in advance the detailed steps in fitting the French curve to the points on the layout construction lines. See Figure 2. In the construction of an ellipse, for example, this analysis showed that the use of the French curve involved the following steps:

1. The determination of points through which the ellipse curve must pass. The method of performing this instruction is a separate problem.

2. Recognition of the parts of the ellipse curve.

3. Selection of one of several French curves that will fit each part of the ellipse curve.
The Construction Lines for an Ellipse
(one quarter of the construction is shown)

Figure 1

Fitting the French Curve to a Set of Points

Figure 2
4. The method of fitting the correct part of the edge of the selected French curve to the determined points on the layout.

5. A desirable method of drawing the curved line with a pencil. (The use of a ruling pen and ink is a separate technique.)

6. The method of joining the ends of parts of the curve.

Attempts were made to solve these problems by a number of teaching methods. Class demonstration at the blackboard was attempted by using the largest available French curve (approximately 10 inches long). This method was a failure. Only those sitting in the first row of drawing tables were able to see even a part of the demonstration well enough to make it of any value to them.

Better results were had when large plywood curves, approximately 30 inches in length, were used. These plywood curves were of the same shape as the French curves but were large enough to give better effects at the blackboard. They were made by using the pantograph to enlarge the outline of the small celluloid curve. The resulting outline was transferred to the plywood from which the large curves were cut.

The construction lines for the desired curve were then drawn on the blackboard and the large wooden French curve was applied to these points to show the student that its edges should touch three or more points on the layout.
lines. This demonstration method was an improvement because more students could see the process, but the large curve was awkward to handle and was very artificial. It proved difficult to show to all the technique of sliding the curve along the pencil (represented at blackboard by the chalk) until it fitted three or more points on the layout lines. This is one of the important techniques discovered, partly through the search for better teaching devices as part of this study, which simplified greatly the learning problem for a student. Experienced teachers know the difficulty of describing a process and even Confucius recognized this problem in his famous, and oft-quoted statement, "A picture tells more than 10,000 words".

The first film was taken to fill the definite need of a better method for teaching the use of the French curve, and to test the use of motion pictures as a teaching device in the drafting room. It was planned to follow a good learning order and to fit a proper and efficient tool technique. The picture was to start with the layout of construction lines for an ellipse (drawn by the parallelogram method) and was intended to demonstrate the way to use the French curve while drawing the ellipse.

How the Teaching Film Solves the Teaching Problem. After seeing the film, there is a feeling of confidence on the part of the student draftsman because he learns detailed
methods in the film that are essential when drawing the ellipse, as well as in other uses of the French curve. Some of these conditions are:

1. He sees, in the motion picture, the drafting and the drafting equipment in approximately the same size and in the same relation that he sees his own drafting board and drafting equipment.

   There is a strong element of realism to such a picture. This, added to recognition of the sameness of the problem he has been facing, tends to personalize the film to him.

2. By using a telephoto lens of suitable focal length the film shows a close-up which enlarges the penciled construction or layout lines so they show as clearly as if they were drawn on the paper he is using for his own drawing.

   This further heightens reality and personalization of the action.

3. He can see the position of the points on the construction lines used to locate the points on the ellipse curve with complete clarity. This was impossible from the blackboard because the weight and size of the wooden French curve required the demonstrator to assume positions that hid parts of the construction lines.

4. The highly important detail of setting the pencil on a point, then sliding the curve against the pencil until the edge of the French curve fitted three or more points in the desired ellipse is shown clearly and completely in the motion picture. This detail of action is very difficult to explain in words or to demonstrate at the blackboard. This is one of the most valuable details of workmanship that enables easy and successful use of the French curve.

   It is certainly not feasible to show such action in a teacher-illustrated lesson and it is improbable that many commercial artists are able to more than hint at the smooth flow of motion shown so easily in a few feet of easily-taken film.
The Animated Film. Many processes, particularly those of geometric construction and of certain methods of projection in which a definite sequence must be followed for their satisfactory solution can be shown better in the form of the animated film rather than by the use of the natural motion film which shows the hands manipulating drawing tools and instruments. With suitable subtitles or accompanying discussion, the steps in the process can be shown easily and clearly. Pauses in the animations separate the process into its logical divisions. By the development of techniques special to animation, the drawing tool or instrument can be shown in place performing the operation that it will normally follow in making the drawing. An added interest is given to the picture by the unique operation of an instrument going through a process without visible means of support or of handling. This makes the action more vivid.

How the Animated Film is Taken

An area of teaching that seems easy to present by ordinary demonstration and explanation is that in which the student learns to draw tangents. Yet this technique gives constant trouble to students in making their drawings. Tangency is of major importance in drafting since it is a process which must repeatedly be used in making drawings.
It is important that a student learn the detailed methods of laying out the construction lines that he must use to find the centers for the tangent areas as well as to fix the skills needed to draw a satisfactory tangent. Thus, the problem resolves itself into two parts; one, instruction in the steps of a process; and, two, instruction in the detailed steps that make up the skill.

A film was needed which would show the geometric construction for certain commonly-used tangents. The demonstration was to show the constructional process needed to find the center for a compass curve used to round a right angle corner. It was decided that this could best be shown by an animated type of drawing chosen because it made possible the clear isolation and definition of the steps in the geometric process.

The analyses of the tangent layout and of the drafting technique needed to draw a tangent curve for rounding a square corner highlights the problem.

The layout of construction lines is illustrated in Figure 3. It consists of the following steps:

1. The outline of the object is drawn in light construction lines. The corners to be rounded are drawn square, (as right angles).

2. A measuring line is drawn on which to set the compass to the radius of the arc to be used to round the corner.
1. These lines show the corner that is to be rounded.

2-3. The radius is marked on the measuring line.

4-5. The compass is set to the radius on the measuring line. The setting is tested.

6. Two arcs are drawn across the corner outlines at A and B.

7. Points at A and B are used as centers for the arcs C and D.

8. The center for the arc used to round the corner is where C and D cross.

Steps in the Process of Rounding a Corner

Figure 3
3. The scale is set on the measuring line. Two marks made across the line are the radius distance apart.

4. The compass is set to the radius.

5. The setting of the compass is tested for accuracy by drawing a short test line through the measuring mark on the measuring line. The compass remains at this setting throughout the remainder of the problem.

6. The compass is used to make measuring arcs across the edge lines the radius distance from the corner.

7. These marks are used as centers from which two short crossing arcs are drawn. This intersection is the location of the center for the desired arc which shows the rounded corner.

8. This center is now used to draw an arc that starts on the mark on one edge line and ends on the mark on the other edge line. This arc, which is tangent to the two straight edge lines, shows the finished rounded corner.

Use of the animated film was found to focus attention on the activity included in the process without the diversion of attention caused by details of the drawing board, hands, clothing, etc.

The natural motion type of teaching film was found to be impractical in many cases because the position of the camera and the supporting tripod interfered with the workman who was being photographed. In other cases the position of the workman obscured or completely hid parts of the process. By use of the animating technique, the camera is placed in an ideal position to show clearly
the entire process and is solidly fastened so that good quality pictures can be taken. All of the process photographs easily and clearly during animation. The speed at which the process moves is easily controlled.

During the development of this film, the necessary construction lines were drawn in pencil and photographed. They projected so poorly that the film was found useless for demonstration before a group as large as a class. A series of tests were run on the animating board to find the proper width and kind of line to use for animation. Details of this process are explained by Speer (15:46). (The writer assisted in directing Mr. Speer in his research while preparing an excellent study of the use of animated motion pictures for teaching sheet metal drafting.) Lines and letters were drawn on light weight bristol board in India ink with the Gillotte 404 lettering pen, the Leonhart 718F pen, the ball point pen, and the Speedball pens from the small No. 5 on up to the wide No. 0. Tests for line widths were made also with showcard brushes that produced lines varying in width from one-eighth inch to one-half inch. Satin finish showcard black water color was used with the brushes and in some cases with the speedball lettering pens.

Test photographs were made on Eastman positive film. The test lines were numbered so they could be
identified when the developed film was projected and a selection could be made of the proper line widths for use in the animated drawing. Lines about one-eighth inch in width were selected for construction lines. They were made with a medium sized speedball pen. Wider lines were used to show the finished parts or main outlines of the drawing. These were made with the showcard brush and were about three-eighths of an inch wide.

How to Operate the Animating Equipment

Animation is made possible by a single-frame attachment on the motion picture camera. See the drawing, Figure 4. This attachment consists of a plunger operating against a spring which in turn releases a trigger. The trigger presses down the operating button of the camera with a quick, snapping action, releasing the camera shutter long enough for one frame of the film to be exposed.

All of the animations in this study were taken by means of an animating device attached to the Bell and Howell camera. The camera was attached to the animating device with the lens four feet above the cardboard upon which the drawings were made. A one inch lens with an F 3.5 stop was used for animation. The operator was seated in front of the board where he could make adjustments in the equipment, draw lines, and move letters.
The Single Frame Attachment

Figure 4

The Rotating Pin Used in Animation of a Compass

Figure 5
The operating sequence was as follows:

1. The operator would draw a line, would add to its length, or would move an instrument to a new position.

2. He would then remove any pens, drawing equipment, his hands or his head from the area in the picture.

3. He would next turn on the photoflood lamps and finally press the single frame button to take a single photograph or "frame" of the "action".

4. He would repeat this sequence of operations for every part of the motion to be photographed, drawing in each part or moving the instrument to its new location between each exposure.

When the first series of films was completed, developed and projected, it was found that lines drawn for animation should increase in length about one-eighth inch between each single frame if the speed of the animation when seen by the student was to be satisfactory and understandable. When longer lines are made between each frame, the action becomes rapid enough to confuse the student watching the process. The details of the process occur and are gone before they can be recognized.

Animation must occur at a speed that is slow enough so the student can watch the whole process easily. He must first be able to recognize and examine the situation and to find the line that is to move. Then he must be able to follow the animation without being hurried.
When the motion is completed, he must be able to look back over the finished line and to recognize what has been done.

Motion may be varied in different parts of the film both to add variety and interest to the method of presentation, and to give importance to the line in the learning process.

An example will make this clear. When setting up the tangent problem, lines were drawn to show the corner to be rounded. Since these were the first lines to be drawn on the picture, no confusion occurs if they move faster than later lines. These lines were drawn with increments varying from one-fourth to one-half inch. Long lines that progress slowly are monotonous to watch if the increments are as short as one-eighth inch. They will rush across the screen at too fast a rate if the increments exceed one-half inch per frame.

Parts may be stressed in the film by the use of wide and narrow lines as well as by varying the speed of motion, i.e., by varying the length of increment between exposures in taking the film. Attention may be directed to important intersections of lines, to measurements, and to other details of the process by moving arrows up to the point or to the intersection.

Let us examine the application of these principles to the making of the animation of tangent construction.
The lines drawn to indicate the location of the rounded corner are purposely made narrow since they are to be light construction lines on the student's drawing. The measuring line is also a narrow line. The draftsman's scale, shown at the lower edge of the picture in which the radius measurement is taken, illustrates a technique seldom grasped by the student from the usual textbook and demonstration. It is a common practice among students to set the radius of the compass by sticking the needle point of the compass into the scale at the zero mark and attempting to set the radius on the scale itself, a method both inaccurate and damaging to the scale.

The desired method of drawing a measuring line on the paper and of setting the compass on this line is thus shown on the film as an incidental part of the animation. Later, in the discussion of the teaching method, an explanation is given of the use of films to bring out an excellent review of basic drafting methods and practices.

These lines, all basic to the construction of the tangent, proceed at a reasonably rapid speed. The construction lines, which show the setting of the compass to locate the different centers, proceed more slowly so the student can re-orient himself. It is important to bring all action on the animation to a definite stop after each step of the process has been completed. There is a tendency,
when the lines grow too rapidly, for the observer to lose touch with the action. Frequent stops are needed to allow the student to look back over the completed lines and to study the other completed parts of the animation. This is a distinct integrating process and a very necessary one to a clear understanding of the lesson.

It is desirable to expose from twenty-five to fifty frames of each completed part of the animation so that the student will have time to examine the completed lines and to appreciate their relation to other parts of the drawing before the next part of the process is started. This is done by holding down the operating button and allowing the camera to run continuously while the artist doing the animation examines slowly each line or part just completed. He may do this slow inspection twice if there is any doubt in his mind as to the student's ability to recognize all of the parts of the construction so far completed in the time he has allowed for the step.

The same procedure should be followed at the time a tool or instrument is moved to a new position for a new sequence in the animation. It should be allowed to remain in the new position long enough for the student to examine and recognize it before the new sequence of the animation is started.

A convenient method of calling the attention of
the student to centers or to points on the drawing is to move a small arrow into the picture so that it touches the point where the attention is being directed. This was done to show the first center to be used in the animation.

After the compass had been made to animate a curved construction line, the camera was run for a number of frames so the student watching the projected picture could examine the whole picture, look back for the starting point, and run over in his mind the process up to that point. The arrow may again be used to trace over the line, to review the motion, and to allow time for the necessary explanation when the film is used for demonstration. This device is useful when an explanation or other break in the process occurs.

The length of these runs was varied with the detail and intricacy of the preceding animation, and with the amount of material already on the drawing. A like procedure was followed at the end of the whole picture when seventy-five or more exposures of the completed drawing were run through the camera so the completed animation could remain on the screen long enough for the student to study it.

Animation of Tools and Instruments

Much interest can be added to the animated film
by using some of the instruments to measure or to draw lines as they are used in ordinary drafting practice. To produce animation of the compass used in drawing the tangent construction, its needle-point was removed and a brad or a drill rod of suitable diameter was substituted to act as a pivot about which the compass would move. One end of this pin, which was about one and one-fourth inches long, was filed to a long tapering point. It is illustrated in Figure 5. The pin was then bent to form an angle of approximately 150 degrees and was set in the needle-point holder of the compass.

The point of the pin was forced into the soft wood of the drawing board for about an inch so that it would hold the compass upright and yet would allow it to be rotated around the pin in the board as a center. This set the compass in a slanting position so that its characteristic shape could be seen clearly from above. All of the action on the animation and the position of any tools or instruments must be chosen with the position of the camera in mind. Set directly above the board the position of the camera requires the animator to plan all of his action as if he were looking at the board from the position of the camera lens.

Incidentally, the use of the bent pin as a center for rotation produced in the animation a remarkably clear
showing of the correct position for this use of the compass. It should be rotated by gripping the handle and "leading it around" as the compass draws the circle.

Dividers, which were seldom equipped with a removable point presented more of a problem when they were used in an animation. They had to be stuck into the board in such a way that their position could be changed to get the effect of motion in the film. To do this one needle-point was bent and stuck into the board. Both the dividers and the compass were moved from one-eighth inch to one-half inch for each single-frame exposure, depending on the desired speed of motion. This speed was determined by the total distance to be traveled and by the complexity of the animation.

Since animation was done on positive film developed without reversal, the effect of color had to be considered carefully. Drawings were made on white cardboard or bristol-board or upon a good grade of white wrapping paper such as Snowflake Bond which would take India ink or satin-finish showcard paint. The paper had to be thick enough so the moisture in the paint or the ink would produce no wrinkling. Erasures were made by painting out lines with showcard white. Care was necessary to be sure the white, when dry, was the same tone as the paper or cardboard. Otherwise the contrast would photograph.
On suitably-chosen paper, light pencil lines used for the advance layout of the animation can be drawn and allowed to remain on the paper. If drawn lightly enough, they will not photograph. A T-square for animation was made of a piece of black cardboard which was moved across the surface of the animation by placing the edge of a regular T-square against the cardboard and moving it into the new position. The regular T-square is removed during animation. Triangles were also made of black cardboard. Pencils or pens were omitted since the effect of the moving line carried the attention satisfactorily, the extra detail of moving a pencil was eliminated, and so made possible greater speed in the production of the picture. Too great realism was avoided, since it was felt that the student's attention should be focused upon the drafting problem being solved rather than on the technique involved in making the picture.

It has been estimated that approximately two hours time was required with the equipment available to produce pictures which are projected in ten seconds. This makes it obvious that the time taken to produce any degree of realism would be undesirable. In its place, an actual photograph of the hand operating the equipment would be preferred. This type of realism was avoided for another reason. The use of an animating technique permits the
necessary lines or equipment to be shown and avoids attention-diverting details such as a ring on the hand or attention being drawn to fingernails.

Animation of Titles

Many interesting results can be obtained by the animation of letters used to form titles. Cost of teacher-made film, the time involved, and the availability of equipment are determining factors in the extent to which animated trick shots and unusual animating techniques may be used. Even so, the factor of teacher production adds greatly to the interest in the film when shown to students.

It may be argued that a sound film would be superior to the silent teaching film. This is true if the film were to be generally used as would a commercially-made film. But the sound track, unless made by the teacher, would seldom fit the needs of the individual teacher or class. While the sound film would eliminate titles and subtitles, yet sound prevents a teaching use which will be described later in this study. The several valuable uses of the silent film will be described later.

Titles selected for these films were kept at a minimum and were removed entirely for certain uses. In some cases, it proved necessary to have titles to explain the action. In the case of the film showing "How to Read
a Scale", in which fractions were formed, numerous explanations gave an opportunity for variation in the action of the letters while forming the words used in the explanations. These variations add much interest to the film but they should be kept at a minimum so that they do not detract from the action taking place in the animation. Their chief use would be for the relief of a monotonous series of repeated lines of letters.

An important secondary use of animating letters in the title is to force the attention of the reader to the lines since his interest can be drawn to them and speculation set up as to what will occur next. This is an effective interest-forcing device.
CHAPTER V

USE OF TEACHING FILMS IN THE CLASSROOM

To find its best use in the classroom the teaching film should be available at the time the student needs it and should interfere as little as possible with his routine activities. Umstattd (16:297) remarks in this connection:

"Visual aids are ineffective unless they can be made immediately available whenever needed."

This immediately sets up a problem in the use of the teaching film. The first difficulty is met when the instructor tries to find a part of the classroom in which to show the film so that sufficient illumination may be had on the screen. Room darkening is, in many cases, a serious problem to overcome and one which is apt to baffle a teacher attempting to solve it.

**Room Darkening.** To obtain the clearest picture the room should be made completely dark. The effect of light leaking into the room around the blinds, at a transom, or through holes in defective blinds, is greatly magnified by contrast in the darkened classroom. This unwanted light immediately sets up serious eye strain which interferes greatly with the appreciation of the picture and diverts the attention of the student. A group watching
the picture in a room where considerable light is leaking in spends valuable time in discussing the cause of the leak and in attempting to remedy the situation. This requires time that should be used in viewing the picture and in studying the information it contains.

One solution for this problem is to install light tight curtains that move in suitable enclosures at the edges which exclude strong light. These curtains are none too satisfactory. When the windows are open for ventilation the curtains blow out of the side guides and are soon destroyed. While not so thoroughly light-tight, the use of heavy cloth curtains is more satisfactory. These curtains are easy for students to operate and the chances of damage to them is very small. They are easy to install and are inexpensive. If properly installed they will be sufficiently light-tight for all ordinary projection.

Ventilation is a problem in any room that is closed so that it can be darkened. The addition of special ventilation controls in or near the classroom in which the teaching films are being shown is obviously impractical, not only because it is expensive but also because teachers, seldom trained for its use, have difficulty with its operation. The ideal visual aid equipment is that which may be picked up and used as conveniently as the teacher would pick up a ruler, a textbook, or a flat picture. These
qualifications immediately point out difficulties in using the darkened room and suggest that under present conditions some other solution might be more satisfactory for classroom use.

If the school is fitted with a theater or with a special room that can be darkened, another complication is introduced. The use of a film for instructional purposes should disturb the learning atmosphere as little as possible. Any showing which requires the students to leave their accustomed working positions and to move into another room immediately sets up a poor learning atmosphere and becomes a possible discipline problem. Valuable time is lost in moving the class to the room where the film will be shown and in getting them settled. There is apt to be a considerable amount of horse play and a request for comics. There is a feeling that this is an entertainment period instead of an instructional period. Such a use of the teaching film proved so unsatisfactory that it was immediately discarded in this study during the testing of these films in the classroom. Instead a silent projector was set up in the drafting classroom and various means were tested for adapting the existing conditions to the use of the film.

Screens and Projection Surfaces. When the films described in this study were first shown no screen was available.
The most obvious substitute was to try the different available wall and blackboard surfaces in the drafting classroom.

The animated films may be projected with considerable success on the blackboard. A slate blackboard is best for projection and the green composition blackboard is the poorest. Projection was tried on plain, cardboard, shipping carton surfaces. This cardboard is light brown in color. Reflection from the surface is fair. Smooth plastered wall surfaces gave excellent results, with progressively poorer results when the walls were of rough finish or when they departed from the light colors. On white surfaces the values of the motion picture showed more plainly and were more satisfactory.

For use with small groups of students, pieces of white bristol board, about 22" x 28" in size proved to be an excellent screen. This cardboard was set up in the chalk trough or on a drawing bench. An excellent screen can be made of plywood that has been sprayed with aluminum paint. Even better is a flat white surface, such as dish blotter, or a matt surface bristol board.

Illumination was satisfactory when these screens were set at a distance of about 10 feet from a projector equipped with a 500 watt globe. Window shades used for screens provided an excellent reflecting surface at night.
but were poor for daytime use.

The teaching film has been used extensively in the undarkened classroom at Stockton by setting up the small screen in a part of the room where little direct light fell on the screen. About a dozen students could watch the showing of a film by this method. Care was taken to prevent eye strain by setting the projector and the screen so that students watching the screen were facing away from windows. The screen was also shaded from the direct light of the window by cardboard or plywood. This gave sufficient illumination on the screen so that the group sitting within ten to fifteen feet of it could see the details of the picture satisfactorily. No complaint was had under these conditions with the intensity of illumination or from the loss of needed detail in the picture.

Probably the most satisfactory results occurred when the film was shown in an undarkened classroom by means of a projection tunnel equipped with a translucent screen. The construction and use of the projection tunnel will be discussed later.

In selecting the conditions under which the visual aid will be used it must be remembered that certain criteria should be met; first, the student should be able to see the picture from his seat. For this purpose some type of screen is desirable. The beaded screen, covered by
tiny circular glass beads, is excellent for this purpose.

Dent (7:113) has this to say about screens:

The beaded screens which have been developed within the past few years and which are used extensively in schools are similar to other screens except that the surface is covered with small glass beads. This type of screen has the highest direct reflective qualities of the three general types - beaded, silver and mat white - but the projection at various angles in the room is not entirely satisfactory. In other words, if the screen is to be used at one end of a long narrow room it will be entirely satisfactory. On the other hand, if it is to be used on one side of a short or square room, those who are seated at wide angles from it will receive a very poor reflection of the picture. Tests which have been conducted by the Electrical Testing Laboratories in New York City indicate that the beaded screen gives the brightest picture for all angles up to 8 degrees; the silver screen is entirely satisfactory at angles up to 30 degrees; and the mat white surface should be used in situations where there will be angles greater than 30 degrees. In most cases the angle of reflection will not be greater than 30 degrees so either the silver screen or the mat white will prove to be satisfactory.

Silver screens ... are screens which have a metallic coat. These screens are flexible and will permit rolling without damage to the surface. The angle of reflection from the silver screen is greater than the angle of reflection from the glass beaded screen, so this type of screen becomes more satisfactory for the large and almost square room where it is necessary to have a reasonably wide angle of reflection. The chief claim for superiority on the part of the beaded screen is its brilliance of reflection through a rather narrow angle. If extreme brilliance is not required, the silver screen will prove to be just as satisfactory.

A screen for class use should be approximately
6 feet by 8 feet in size and should be mounted so that it can be rolled up for protection. Since such a screen is expensive it may be difficult to obtain one for the average classroom. Some degree of room darkening is desirable when the beaded screen is used. Classrooms equipped with Venetian blinds may be darkened enough to allow the use of the beaded screen. However, enough light enters through these blinds to make it difficult for students in the rear of the room to be able to see the film from his seat.

A second criterion is that the film must be used so that it disrupts the normal class activity as little as possible. To meet this condition the projector may be set up and operated in the classroom instead of moving the class to another room. The class can look up from its work and watch a needed process unfold on the screen. This condition is hard to realize with the present projectors and screens.

For use as an individual teaching device the small screen is entirely satisfactory. With it a film can be shown to a single student or to small groups of students. This screen is so convenient that it may be set up by the student and the equipment prepared for action with a minimum of class disturbance.

The Problem of the Projector. The use of the teaching film at Richmond and at Stockton presented a difficult problem
because of the projector. At Richmond the projector owned by the school was large enough to be difficult to handle when carrying it between classrooms. This projector was much used by the science department as well as for projecting films of general interest to the student body. When needed, the projector had to be carried from the science building or from the office. The time and trouble required to get the projector and to set it up made its use inconvenient and greatly restricted its value as a teaching device in the drawing class. At Stockton, with several projectors available and the teaching films in constant use in the drafting room, the projector was kept in the drafting classroom. This arrangement made it possible to thread and to use the projector whenever it was needed. Under ideal conditions the projector would be left in the classroom so that its use is simply an incident in the days work which blends smoothly into the class procedure. The teaching film then becomes a true teaching aid and is in no way a special event.

The Silent Film Has Advantages. As has been mentioned elsewhere in this study, the silent film has certain advantages over the sound film. Dent (7:136), in discussing the relative values of sound and silent films, says:

Embattled on the one side, we find those who claim that sound detracts from the instructional
value of the motion picture instead of increasing its teaching value. Entrenched on the other, we find those who claim that recent developments in educational sound films have relegated the silent film to obsolescence. But there are forming larger forces than those of either of the belligerent factions who believe that both the silent and the sound film have certain definite valuable functions to perform— that each has its place and there is a place for each. The author chooses to cast his lot with this larger group, not for safety, but because of an honest conviction that neither the sound nor the silent film, alone, can accommodate the requirements of schools as adequately as both.

Technical difficulties and the expense of suitable equipment for taking a sound film makes its use impractical in the average classroom at the present time. It is interesting to note that portable and inexpensive recording and play-back equipment is becoming available so that sound-on-record may soon be added to the teaching film. The adaptation of sound to these films could well be the basis of a future study.

Suitable silent projectors for classroom use may be had at reasonable cost. For an experimental program, such as the one described in this study, a reconditioned projector is more suitable than is a new projector, because it can be placed in the hands of students more satisfactorily than can a new projector. This permits the use of the teaching film in many schools where expense is an item to be watched carefully.
The Problem of Outlets. Projectors that are equipped with cords from 10 to 20 feet long present no problem because such a cord will reach some available outlet. When a film is used in a classroom that has no outlet, or in which none are located at suitable positions, suitable extension cord must be made up to reach to the position chosen for the projector. In planning a classroom where visual aids will be used a number of outlets around the room are desirable. A minimum of two outlets is mentioned by Dorris (S:172-173):

In wiring classrooms it is wise to have outlets at both the rear and the front of the room. The baseboard socket is the most convenient for any type of classroom projection; it is handy to get at; extra cord can be flat on the floor; and there is less danger of tripping over cord and upsetting lanterns. Some prefer to have the cord suspended directly over the projector.

Later in this chapter we will discuss the use of the film at the student's desk. It is easy to equip either the projector or the special device used for viewing films at students' seats with long enough cords to reach the available outlets. In the average drafting class the student spends the major part of his time at his desk working on his drawings so the problem of cords laid on the floor is not a major one.

The Use of the Film to Present a New Topic. A new topic normally is presented to the class in the form of a lecture
accompanied by suitable board diagrams and drawings to illustrate the steps in the process and to show methods used in constructing the different views. The difficulty, mentioned earlier in this study, of adequately prepared drawings to accompany the lecture is overcome by the use of the teaching film. The teaching film that is to show the steps in drawing a geometric figure or to illustrate the method of obtaining a sectioned view is carefully planned before the original drawing is made. The resulting film shows a complete, carefully organized series of steps which is much better prepared than is the impromptu presentation of the typical board demonstration.

Tests in using this type of film show that the film should be shown to the class several times before the lesson may be considered complete. In commenting on this fact, Dorris says (8:193):

To be of the greatest service, a film that presents considerable information should be projected at least twice for definite periods of study. Each presentation reveals new truths and arouses new interests, calling for more detailed study. Therefore after the first presentation, ample time should be allowed for cooperative discussion . . . before the second projection of the same film is given.

The second presentation of an educational film often secures more valuable results than did the first. It is during this second study of the film that any erroneous impressions may be corrected, and a better opportunity is afforded for comparison and verification of data. It has
also been found that lessons are far more valuable if the teacher emphasizes a point here, or calls attention to an important fact there, that might otherwise be overlooked. Discretion must be used, as an excellent film lesson might be ruined by the incessant talking of a teacher.

A somewhat different technique than that outlined by Dorris will be used for the drawing type of film. In the drawing film every line is of major importance. No line may be left out if the drawing construction is to be complete. The student's problem in watching the drawing process unfold is; first, to recognize what is happening; and second, to make any integration that is necessary for him to understand the relation the different lines have to one another.

After a short discussion of the problem that is to be explained by use of the film, enough discussion is held so that the instructor may be certain that the class understands the purpose and content of the film. This may be considered as a mental road map that is given to the class before the film is shown and on which certain important stops as well as different points of interest along the way are called to their attention. Now, with the projector threaded and the room properly darkened the instructor takes his place near the screen (so that both sight and hearing can be focused on the picture). He directs the student, who is operating the projector, to
proceed with the picture.

The instructor follows the picture as it unfolds with a running comment in which he explains the relationship of parts of the drawing, the reasons for each part, and the results to be expected from the drawing process that is being shown. He should avoid carefully a monotonous repetition of statements of fact, of repeating in words what the student can see so much better while watching the picture. The technique of talking with the picture has much importance. The commentator should view the film and be thoroughly familiar with its content before attempting to show it. He can then time his comments on the action of the film and complete his remarks when the action is completed. His comments may never extend beyond the action and run into a part of a following action. Neither should his comments be confined completely to the film itself. An effective commentator may bring in many interesting points as he runs through the picture to add to the interest of the group, and to couple it more closely with the work they are doing on their drawing boards.

During the showing of part of a film that the class has difficulty in understanding, the instructor should request the operator to reverse the projector and run the film backwards past the point of difficulty. If the projection light remains on, the action seems to erase
itself from the screen and often produces an amusing situation. When a picture has been taken of a person drawing a line, reversing the machine causes the pencil to erase the line. The student operator may place his hand in front of the lens of the projector until the action has been retraced if the class has a tendency to become boisterous. Then, when he reverses the machine, the action starts over again and the discussion can be resumed, repeated, or new points brought out during the second showing.

Any part of the film which the class finds obscure can be repeated over and over again until it is understood thoroughly. Normally, repetition should not occur more than three times, since part of the class will have grasped the point on the first or second showing and will become restive during repeated showings. Under these conditions the student needing further help should view the film on the small screen at the end of the demonstration.

The purpose of the first showing is to introduce the topic and to give time for recognition and partial integration of the information it contains. When the film has been run through completely, it should be discussed briefly. The student operator will take two or three minutes to rewind the film and to rethread it through the machine for another showing.

During the second showing the students are
cautioned to watch for any points that were missed on the first showing. There should be little discussion during this showing. Before the second viewing of the film their attention may be focused on the action in the film or on the relation of its parts, by telling them to be ready to explain the action of the film during the third showing. The film may again be stopped or reversed to clear up any point requested by members of the class. While the film is being rewound and rethreaded for the third showing they will have time to think out the parts of the process.

During the last showing some student is selected to take the place of the teacher as commentator. This student may explain the whole action or a different student may explain each separate part of the film. It has been found that students enjoy this type of showing and that it causes them to be alert during the first and second showings to get all the points involved in the film. It has proven to be a fine motivating device and one that fixes attention unusually well.

The teaching type of film which shows the tool techniques or the adjustment of equipment as well as the animated type of films are excellent to use for class demonstrations, for single students, or for small groups of students. The process was used at Richmond largely for class demonstration, but has been found to be equally
successful at Stockton when small groups were ready for the discussion. The same technique has been used with equal success in teaching graduate classes at Corvallis.

Use of the Film by Individual Students. One of the outstanding values of the teaching film occurs when it is used for individual instruction. It may be used to repeat a lesson to students who have been absent at the time of the demonstration. Other valuable uses of the film become possible when the class is taught on an individual basis, with each student working at his own speed. The most outstanding use of the film for individual instruction is made possible by the film viewer. Many possibilities are realized when the projector is used with a small projection tunnel. Still other uses occur when the film repeater is used with the projector. We will first consider the operation and possibilities of the projection tunnel.

Use of the Projection Tunnel. One of the most effective ways for the individual student to view a film in the undarkened room is by means of the projection tunnel. Essentially, the projection tunnel consists of a small screen protected from unwanted light by means of the opaque surfaces of a three-walled tunnel. The diagram at Figure 6 shows such a tunnel. The tunnel used at Stockton was made of heavy cardboard. A translucent screen, made of tracing
The Projection Tunnel in Use

Figure 6
paper or tracing cloth fastened on a frame, is set in near the center of the tunnel. The wide opening of the tunnel allows a group of students to see the picture, yet stops light from reaching the screen. The tunnel was made so that it would fold for convenient storage.

The student sits facing the tunnel so the light from the projector reaches him through the translucent screen. More light is transmitted through the translucent screen than would be reflected from an aluminum screen or a beaded screen. A disadvantage of the translucent screen occurs when it is used for larger groups, because students sitting at either side rapidly lose illumination and get a poor view of the picture.

Students move their drawing board, tools, and equipment to a bench in front of the tunnel to watch the film. They ask the instructor to reverse and repeat parts of the film as many times as is necessary to get the information contained in the film. The student may explain the film after viewing it as was done in the class demonstration.

When used in this fashion the film requires the teacher's time or the time of some student foreman to set up and operate the machine. Under ideal conditions the projector should be simple enough so that any student could easily thread and run it without damage to the film. At
present this is possible but hardly advisable because the projectors are still too complicated for such use, and there is still the possibility of damaging the film. This difficulty is overcome when the film repeater is used with the projector and the projection tunnel.

The Use of the Film Repeater. It would be desirable, when using the projection tunnel, for the film to continue running while the student learns the contents of the film. This would release the instructor or the student foreman for other activities. Such a use of the film is possible when the repeating device is set up with the projector. Speer (15) found, in making his study of the animated film, that the repeater developed at Stockton by the writer in the process of this study, was a rediscovery of an idea originally worked out by Edison. The repeater, as developed at Stockton, consists of a base on which the projector is set. Attached to one side of this base are two separate sets of supports that carry a series of film spools. The lower support is fastened to the side of the base. The upper support slides on two dowels, so that it can be raised or lowered during use. Two thumb screws are arranged to clamp the upper support to the dowel spreaders. The repeater is shown in Figure 7.

The spools are grooved to support the film only on its edges, so that no scratches will be made on the
The Film Repeater and the Projection Tunnel

Figure 7
emulsion or on the clear celluloid back surface as the film runs through the repeater. The spools must be reasonably large so that the film is bent as little as possible in going over them.

The film, instead of being wound on a metal spool, is spliced together into a continuous loop. A strip of exposed film that is totally black, or a strip of leader, is spliced between the ends of the film to indicate the beginning and the end of the action. The film is then threaded on the repeater, running from the driving sprockets of the projector directly to two spools placed on the repeater, so the film will rub against no part of the projector. The remainder of the film then is looped back and forth over the spools and the upper support raised or lowered until the entire length of the film is accommodated. By moving the projector on the repeater base the film is slackened until it will run smoothly through the projector. When too tight, the film will bind and tear when going through the sprockets of the machine. If too loose, it will jump off the spools. Practice has shown that the film may be allowed to run continuously for thirty minutes or more with entirely satisfactory results.

A student wishing to view the film places his drawing board and equipment before the tunnel, turns on the projector, and watches the action on the screen. In
this way he can view drawing processes, such as the construction of tangents. For such use the repeater has been proven to be a superior teaching device. Or a student, learning to form a new letter group, can watch the stroke sequence repeated until it is mastered. One of the great values of the repeater occurs when a technique is being learned that requires drill for mastery. The skill may be watched on the screen, then practiced on the drawing board without shutting off the projector. During the interval following the part of the process that the watching student is studying, the film loop runs through the machine and allows time for the student to practice and experiment with the technique. When confused, he can wait for the action to be repeated, when he can correct the errors in his technique. When he has mastered the process he turns off the projector and returns, with his board and equipment, to his seat. The projector, with no further attention, is ready for the next student who wishes to study this process.

It has been customary during the three hour classes at Stockton, to set up the film repeater, thread the film, and to leave it. Many students move their drafting equipment to the repeater and practice the processes while the picture runs through the machine. This device is of unusual value for introducing new techniques in the use
of tools and instruments as well as in showing details of the processes, such as the construction of tangents or details of the many projection methods commonly found in drafting.

Another value of the teaching film for individual student use occurs when a film viewer is available. The film viewer is probably one of the least expensive types of devices for using the teaching film. It is also the simplest to use.

The Film Viewer. The film viewer is an adaptation of a standard film editor to classroom use that was discovered during this study.

The film viewer consists of two film rewinds and a viewing screen mounted on a common base. See Figure 8. The film, which runs through a sprocket arrangement, actuates a shutter or rotary prism that gives the effect of motion that may be seen on the viewing screen. It was found that an editor with a screen about four inches by six inches in size, or larger, was desirable. The smaller sizes of viewing screens tend to lose the detail of a picture. Illumination is supplied by a 25 or 50 watt globe. There are a number of definite advantages that occur when the film viewer is used. Following are a list of some of these advantages:
Student Using Film Viewer

Figure 8
1. It requires no room darkening.
2. It can be used on a student's desk.
3. The viewing screen is part of the unit.
4. It is easily threaded and operated.
5. There are no complicated switches or controls.
6. It can use any length of film.
7. It is difficult to tear the film.
8. It takes up little classroom space.
9. It is small and compact.
10. It is simple and has little likelihood of trouble.
11. A film viewer costs less than a projector.

How the Film Viewer is Operated. The student who wishes instruction in a process such as the method of drawing the hexagonal head bolt and nut sets the film viewer on his desk where he can watch the drawing process on the screen, and so he can work on his drawing after he understands part of the process.

After the film is threaded, either by the student or with the assistance of the instructor, the film is drawn through the machine by turning the rewind handle. The present projectors require some practice to accustom the user to the proper operating speed and to the maintenance of suitable tension on the film as it runs into the viewer. The student can reverse and review any part of the film, or
the entire film may be rewound so that it can be repeated. The viewer is small and light so that a student can handle it easily.

An interesting sidelight may be mentioned here in the use of the films as brought out during the course of this study. Generally, boys worked singly when the film was viewed by means of the repeater or the tunnel. Girls, on the other hand, seemed to make use of it in groups of two or three so they could discuss the film and the techniques or processes that it was showing.

A disadvantage inherent in the film viewer is the size of the translucent screen which prevents more than about three people from using it, because the image rapidly is lost as one gets away from the direct rays of transmitted light, so that persons standing on either side can see little or none of the action.

Experience gained during the study would indicate that desk use of the viewer would be more desirable in the average classroom than for the student to leave his desk to use the viewer. An intriguing possibility of the viewer lies in its adaptation for use as a repeater. This might be done by the addition of a suitable container into which the film could feed and from which it could be drawn as the user cranked the rewind device. Such an arrangement would necessitate several minor changes in the rewind and
Use of the Teaching Film with Instruction Sheets

It is a widely accepted fact, as explained by Dorris (8:v-vi), that the film is not an end in itself. It is simply another device that aids the good teacher in getting to the mind of the uncertain student a clearer and more complete picture and understanding of the process or technique or the description that he needs.

The endeavor of every progressive teacher at the present time is to plan school work so that pupils may master it much as efficient people outside the schools master their tasks. This is accomplished by giving children a fundamental understanding of the motives that underlie the work they do, so that there is implanted within themselves a never-failing source of inspiration to carry on.

The teacher who has succeeded in this high endeavor finds in visual instruction one of the strongest methods of prompting natural learning and the proper motivation of the pupils efforts; and in visual aids she finds the most efficient instruments wherewith to bring vividness and concreteness to the child in his attempts to learn. Through its use in modern education, many economies are made possible; for it naturally follows that results are more definite and are secured in much less time. Indeed, if visual aids are sufficiently and properly used, the greater load put upon the school in recent years may be satisfactorily carried without prolonging the child's period of training and with much greater benefit to him in equipping him for life's duties.

The effectiveness of the teaching film can be
increased by the use of the written teaching aid prepared as part of the teaching unit which includes the teaching film. There are many forms in which the written aid can be built. A lesson may be written to explain the method of drawing an ellipse with a French curve or how to draw a curve tangent to two lines. The process is explained in detail in the lesson sheet which is written to follow good teaching practice and to conform to the teaching film. The student who easily comprehends written materials will get results quite rapidly from reading the lesson sheet. For him, the visual aid is an added assistance and a teaching device which confirms the correct methods he develops from his reading or drafting practice or which corrects methods that he has developed either from a poor reading technique, from lack of understanding of the explanations, or on account of lack of instructor supervision and checking.

It is common to find students sitting before the film repeater reading the lesson sheet and watching the film alternately until they are satisfied with the method that is shown.

The teaching film has furnished a valuable adjunct which permitted processes hard to describe and to illustrate in a text to be shown in the form of motion. No effort was made in this study to determine the desirability of showing first the film or to encourage the student to
work from a lesson sheet before seeing the film, rather the film was treated as an additional teaching aid to be used as needed to assist the student in understanding the information contained in the lesson sheet and in grasping the sequence of operations.

Use of the Film as a Remedial Teaching Device. Review in drafting is as necessary as is review in other learning situations. The student, who for one reason or another has had insufficient time or information to practice a process until he has mastered it, loses his proficiency in the technique or forgets the sequence of operations. The instructor can observe easily when grading drawings, or when observing the students at work at their desks, that certain parts of the lessons lack sufficient clearness to the student. Several ways may be used to observe that the student needs remedial instruction. Boys who copy the work of other students; those who spend much of their class time visiting and watching other students work; those whose drawings have been erased frequently; and those who report that they could not make the drawing, need remedial instruction or further complete instruction. The film is an excellent remedial teaching device because it can be used as a rapid method of reviewing material that the student has misread or misunderstood in their text, in their lesson sheet, or from the original demonstration. It offers him a chance to
rebuild his understanding of the material. This is particularly true of geometric solutions in which a rather complicated process must be remembered. One difficulty in teaching geometric processes occurs since many processes the student should know are seldom used in the problems selected for most drawing courses. Under these conditions the student gains insufficient practice in constructing these geometric figures. By using the teaching film as a remedial device the student can in a few minutes review the entire construction, or part of it, seeing it repeatedly enough to fix in his mind the necessary process. The film viewer may be used at his desk while he practices making the construction, or the film may be used on the repeater.

Other opportunities for the film as a remedial device occur in the review or reteaching of instrumentation techniques and in lettering instruction, to mention but two outstanding areas of difficulty. The detailed uses of the teaching film as a remedial device has been but barely touched in this study. It is susceptible to great expansion and needs extensive further study. Dorris (8:7) may be quoted on this point:

... The results secured with any educational tool depends chiefly upon its judicious application in a given situation. How it is handled is an important factor ... On account of their newness and complexity a special technique must be developed for their use, in order to gain the maximum efficiency with the least
expenditure of time and energy. . . The serious and difficult problems are how to improve the quality of the materials and how to use them most effectively in teaching.

Use of Films for Teaching Lettering. The whole problem of lettering might well be made the subject of a separate study. This is one of the most difficult areas to teach and one that has far too little attention and development. Formation of letters offers a number of difficult teaching and learning problems. If we were to analyze these problems, we would find that one learning the form of letters must understand certain design principles commonly taught in art courses. These principles have to do first with the recognition of the relation of space areas enclosed within the letter outline, and involve such things as the balance of one area against the other, the outline shape of the area, as well as the so-called motion produced by the relation of straight and curved lines inherent in the letter shape.

This information is difficult to impart without first providing the student with an excellent background of design principles. It is the writer's belief that this material can be condensed and built into a form suitable for the use of the drafting student. As such it should furnish him with the basis for appreciation of letter design.

A second major problem of teaching lettering is
to show by some convincing means the important facts about stroke order. This information should be imparted in such a way that the resulting poor letter shape due to improper stroke order, or to inefficient working methods, can be clearly shown and, by contrast, the desirable results of using a more efficient stroke order. This brings out one of the great advantages of the teaching film in that it makes possible the enlargement of the pencil point to a size that shows the smooth sequence of motion in forming letter shapes. The camera can be set in an advantageous position, to show clearly the action of the pencil in forming the letter shapes. This action is hidden from the student by the position of the instructor's hand, arm, and body.

The difficult techniques of the use of ink with the different types of lettering pens, the use of color and brush in the formation of letters, the delicate details of touch and of stroking to get finished corners and serifs on decorative letters, details of technique in the formation of curved parts of letters and of stroke joinings, are easy to show in a film, a few feet of which tells more than any amount of explanation or demonstration. The possibilities of slow motion studies in this field are tremendous. Much of the technique involved in brush work occurs so smoothly and at such a speed that it is extremely
difficult to see during an individual demonstration and it is almost impossible to explain in words. Other possibilities that might be mentioned are color mixing, care and conditioning of pens and brushes, operation of the silk screen, etc.

Animation was used during this study to produce a series of lessons on the method of making one group of letters.

Producing Films as a Teaching Method. Perhaps one of the most effective ways of teaching drafting occurs when either the class or a small group in the class undertake the writing of a script and the taking of a teaching picture. There are a number of reasons why the preparation of the picture is valuable. It is unusual for a high school student to be able to analyze the drawing process because he is either learning them or is concerned with the mastery of techniques and is busy with practice on the drawing board. After he has had some experience in making drawings, he is ready to perform the analysis needed in preparing a film.

The group of students may be directed while planning the script, through a considerable amount of research in all available references, to find the most desirable techniques to use in this film. This makes possible a comparative study of methods advocated by different authorities in the drafting field and provides
motivation for the analysis that would be hard to supply by other means. Another value comes from the interest of some member of the class who has had considerable experience in photography and who can act as the cameraman. The selection of camera angles at once raises an important problem in the best positions to use for showing the desired parts of the technique. This is valuable since it focuses attention on the details of the technique that otherwise are often considered hurriedly, if at all. It will be found that each motion, each sequence of the technique, as well as the end result obtained by variations of the process will be thoroughly discussed and a final selection made on the basis of the judgment of the group taking the picture.

It is advisable to take more footage than will be needed in the completed film so that cutting may be done as a part of the editing process. Titles must be selected after a decision as to whether they will be used or not. This forces a discussion of the relative values of titles and subtitles as against their entire omission, so that the film can be used as a demonstration device either for individuals or for the class. An interesting value of the teacher-prepared or class-prepared film is the recognition by students in the following semester of student-actors appearing in the film. This gives it a personalized
element that is lacking in any of the commercially-prepared films.

Films were planned not only to act, when completed, as a teaching device, but also during their making as an interest-builder and as a means of vitalizing the work in the drafting class. This was done by allowing students to plan the "script" for the picture as well as to be actors in it.

The process to be shown in the film was carefully discussed and planned by the instructor and the student actors. Then an outline of the contents of the film was set up. Finally, the procedure to be followed by the students taking part in the making of the film was carefully planned and practiced before any attempt was made to do any photography.

This method was used to film many of the units shown in this study. Students were chosen for the privilege of acting in the film showing the construction of the ellipse who had shown better than average results in their drafting. They had been successful in drawing the ellipse and were able to use the French curve with some degree of skill. They took their privilege very seriously. Discussion of the detailed methods and of the correct procedures to be shown in the film brought out the important parts of the process and proved to be a valuable learning unit for them. They discussed in detail points about good
draftsmanship that were not mentioned in any text or other lesson material. They considered details of procedure and technique that showed surprising grasp of principle as well as of drafting practice.

Throughout the development of these pictures, the students showed the highest interest in assisting in the preparation of the script for the picture and they developed an unusually keen insight in the details of the drafting processes they were to film. The exhaustive discussion and the detailed consideration of methods that were brought out and studied proves that the process of taking these films is an excellent teaching device.
CHAPTER VI

SUMMARY AND RECOMMENDATIONS

The Study Summarized. The changing concept of education in which is emphasized the requirements of the non-college high school student is forcing a new consideration of the teaching problems that arise in the drafting class. We no longer can expect the student to accommodate himself to the drafting course; instead we must be prepared to fit the course to the student. This concept immediately focuses a new light upon the content of the course and on teaching methods.

In making this study the need for a better handling of difficult areas grew out of years of teaching experience and grading of many drawings. Difficult areas were determined by noting drawings which consistently were poorly done or which contained errors. The attempt to find suitable methods of instruction led to the development and testing of many teaching methods and devices which included the use of textbooks, the use of the lecture method, a trial of lecture-demonstration, the devising of loose and bound lesson sheets, and the construction of demonstration equipment. Many drawings in large wall-chart form were drawn; hundreds of lesson sheets were written; and finally, these ideas crystallized into the development of teaching motion.
pictures for use in the drafting class. Since no drafting teaching films were available, suitable films were planned and were taken by the writer.

During the development of the teaching motion pictures it was necessary to design and to construct an animating device and to develop techniques of animating drawings. This led to the testing of suitable drawing papers and boards, colors, pens, brushes, and other necessary equipment. It should be noted that no time was spent in the technical study of motion picture photography. Testing was done on the method of adapting available equipment for teaching purposes and in developing methods of presenting the films in the classroom at Richmond, at Stockton, and at Corvallis, with a consequent discovery and adaptation of the film repeater and the film viewer.

It has been the purpose of this study to re-examine teaching methods as applied to the drafting course. In this process of re-examination the motion picture stands out as a highly efficient teaching aid in presenting the techniques and processes involved in the study of drafting. Incidental to this problem, the study has developed the fact that the teaching film can be prepared by the individual teacher and has detailed the techniques and equipment used in preparing such film. The study has highlighted certain areas in drafting that are unusually difficult for the learning student to master by accepted teaching
techniques and the consideration and development of teaching aids and devices that make more efficient both the teaching and learning process in these areas.

Of striking value is the benefit of the motion picture as a teaching device to the weak student or to the slow learner. Often, the slow learner is slow only because he is a poor reader or one unable to grasp abstractions from the written word and from the commonly used forms of demonstration.

If the highlighting of these education difficulties attracts the attention of educators and results in the removal of them as difficulties to the student, this study will have been worthwhile. If, in pointing the way to a new teaching technique, the learning process in drafting becomes more efficient, the study will have been worthwhile. Attention is called to the group of teaching devices mentioned in the study that allow any drafting teacher a wide enough selection to fit the teaching film into his classroom situation.

Implications of the Study. Facts raised in this study suggest that the whole subject of drafting needs revision, with a searching and skeptical eye cast upon present accepted teaching methods and outlines. That these implications are shared by other than the writer is proven by the wealth of textbooks in this field in which a groping
for new methods and treatment of the drafting subject is evident.

Recommendations.

1. A careful and comprehensive analysis of drafting methods and skills is needed. This analysis should be in such form that it is understandable to the rank and file of drafting teachers. It should be made from a point of view of the student learning drafting, and have as an objective primarily his learning problems. This objective should gradually be transferred throughout the course until at the end of the course it is focused upon practical values.

2. From contact with many projection machines both in the classroom and in teacher training institutions, it has become evident that there is a serious need for an inexpensive yet rugged projector that can be threaded and operated by the average high school student and which will not damage a film. The present projector is too complex, too bulky, and too expensive.

3. Available film viewers need certain improvements to better fit them for student use. Among these improvements are a uniform speed control, a
larger screen, a way to prevent burning film during stops, control of film tension, a safer rewind and a repeating device. This machine also must be simplified and reduced in cost.

4. Teaching films are needed as indicated in the appendix to introduce nearly every topic into which a drafting course is divided. These films also are needed for many areas other than the introduction of new topics. The production of this group of films is a major task and was one which should be done by a commercial producer under the direction of a qualified and sympathetic drafting instructor. It would be a boon to drafting teachers to have this material available and so inexpensive that it could be used as widely as a textbook.

5. The teaching film should be accompanied by correlated textbooks, lesson sheets, and work guides.

6. Until these films become available, film libraries seem a logical source of this valuable teaching aid.

7. It is urged that high schools and colleges provide competent instructors with photographic equipment and materials which permit them to
experiment in producing teaching motion pictures for use in drafting classes.

8. Remedial teaching in drafting classes offers an interesting field for study, and one that should be followed hand in hand with the development of the teaching film and the animated film.
CHAPTER VII

BIBLIOGRAPHY


