

AN ABSTRACT OF THE THESIS OF

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the Use of Animated Motion Pictures"

Abstract Approved: 
(Major Professor)

The problem in this study has been to develop and present a new method of visualizing certain processes in sheet-metal pattern drafting. It has been the aim of the writer to produce a visual aid which will assist both instructors and pupils in this phase of shop work.

Animated motion pictures were the visual aids selected to give this assistance (1) because they are especially suited to line drawings and (2) because they present abstract principles and otherwise invisible processes to good advantage. Sheet-metal pattern drafting is highly technical and is often made up of a series of abstract drawings. For this reason, many pupils experience difficulty in drawing patterns, and as a means of overcoming this difficulty many instructors permit the copying of ready-made patterns. Under this method, students are frequently unable to apply the principles used in making one pattern to the drawing of another involving the same processes. Obviously, there is need for something to clarify these processes. Animation is the only satisfactory means known to the writer by which the various steps can be shown both in the proper sequence and in motion.

During the writer's research on this problem, he found but little published material on the methods of producing line drawing animation for educational purposes. Nearly all of the available information deals with animation for entertainment. To obtain more data, the writer corresponded with several authorities in the field of visual education and with numerous organizations engaged in the production and distribution of educational motion pictures. In response to these inquiries, some valuable information was given which is cited in the thesis. It was evident, however, that few producers

have entered the field of educational animated motion pictures. None of them has produced films on sheet-metal pattern drafting. All expressed great interest in the undertaking, however, and several requested that the films made for this study be sent them for inspection with a view to producing copies and circulating them through film libraries on a rental basis. One company was interested in securing the services of the writer in producing animations for its release. These requests will not be granted, however, until this study is accepted by Oregon State College.

Over four-hundred feet of animated film were produced for this study. The method of production is described in Chapter III of the thesis. Ten units in elementary sheet-metal work were produced in animation. These are:

1. How to develop patterns for cylindrical objects
2. How to develop patterns for cylindrical objects cut off at an angle
3. How to develop patterns for conical objects
4. How to develop patterns for a two-piece elbow
5. How to develop patterns for a T-pipe intersection
6. The parts of a circle
7. How to construct a pentagon from a given side
8. How to construct a pentagon within a circle
9. How to construct a hexagon within a circle
10. How to construct an octagon within a circle.

These ten units produced in animation were previewed by the Seattle Industrial Arts Association on April 11, 1940. Immediately following the preview, a questionnaire was presented to the group, its purpose being to record the reaction to the film. The questionnaire was in two parts: (1) the value of the film as a visual aid, and (2) evaluation of suggested methods of use. The general reaction toward the film was very favorable. One hundred per cent of the answers indicated that certain units of the course could be taught more effectively if animated motion pictures were used than if they were not used. In the second part of the questionnaire, eight methods of use were suggested, and the group rated each method. In compiling the ratings it was found that eighty-six per cent of the answers rated all the methods suggested either OF GREAT VALUE or OF MODERATE VALUE. Of the eighty-six per cent, sixty per cent rated all methods OF GREAT VALUE, and twenty-six per cent rated them OF MODERATE VALUE. The questionnaire and its results are described and evaluated in the thesis.

The production of animated films for classroom use comes within the financial scope of many schools. Those which have a visual education department probably already have most of the equipment necessary for this work. The cost of positive film and other materials needed for producing animation is surprisingly low. The total cost of supplies and developing the film made for this study was \$15.00. Of this, six dollars was spent for drawing supplies, and the balance for film and developing.

The writer's conclusion then, is that such animated motion pictures as he has produced are likely to assume increasing importance in the presentation of technical teaching units.

VISUALIZATION OF SELECTED SHEET-METAL PATTERNS
BY THE USE OF ANIMATED MOTION PICTURES

by

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SUPPLEMENTARY EXHIBIT

Four-hundred feet of animated film on sheet-metal pattern drafting deposited with the Department of Industrial Arts, Oregon State College

VISUALIZATION OF SELECTED SHEET-METAL PATTERNS
BY THE USE OF ANIMATED MOTION PICTURES

CHAPTER I

THE PROBLEM

A. STATEMENT OF THE PROBLEM

The very nature of sheet-metal work necessitates, on the part of the teacher in charge of such work, both specific and extensive knowledge in methods of drafting and making layouts. To secure acceptable results, a certain degree of skill in both teacher and pupil is also necessary. Many sheet-metal problems are, moreover, highly complicated, and involve several processes before the final pattern is completed. Unfortunately, the task of teaching sheet-metal pattern drafting falls on many improperly qualified instructors. It is no easy task for even a well-trained instructor. In the hands of one inadequately trained, its difficulties are multiplied. It is generally agreed by teachers of shop subjects that sheet-metal work is a highly skilled vocation, and that in the school shop, it presents considerable difficulty to both teacher and pupil. It is with these situations in mind that the present study has been made. The problem in this study is, therefore, to develop and pre-

sent a new method of visualizing certain processes in sheet-metal work through the use of animated motion pictures.

B. IMPORTANCE OF THE PROBLEM

Many improvements in teaching techniques have originated in the dissatisfaction of educators with the methods then in use. All too frequently a need for such improvements was felt long before the improvements themselves gained sufficient momentum to enjoy widespread use.

Such is the situation in regard to the use of the moving picture for educational purposes. For many years motion pictures have been used in the schools. Their value is generally accepted both as a teaching aid and as a source of information. Much can yet be done, however, in the improvement and use of motion pictures for direct instruction.

Need for films that serve specific purposes

In examining the literature on educational motion pictures, one is impressed by the large number of writers who emphasize the need for films that serve specific purposes in the curriculum. In this connection, one writer has said: "The present mass of so-called educational and advertising films is a distinct menace to

progress in the use of films as an educational tool".

(10:95) Freeman, Davis, Knowlton, Gatto, Hansen, Arnspiger, and others have made extensive tests to determine the value of certain films for schoolroom use.

(10:95) Concerning these tests, it is said: "These tests are as reliable as scientific controls can devise, and are valid proofs that a certain film has educational value for specific purposes. But we must not commit the serious error of accepting these tests as a blanket proof of the general educational value of all films...." (10:95)

In producing the films on which the present study is based, the writer has in mind the creation of moving pictures which might be classed under the heading "teaching films for specific purposes". (4:-29:43) It is believed that these films are in line with progressive visual education, and that they will serve specific needs in the teaching of sheet-metal pattern drafting.

Some writers believe that teachers themselves should assume increased responsibility in bringing about the much-desired improvement in instructional films. This belief seems entirely reasonable. Teachers are certainly more familiar with the needs of the schoolroom than producers of motion pictures can be expected to be. Lake emphasizes the need for cooperation between educators and

producers as follows:

I am not certain that the manufacturers of school film have been given as much help as they should have been by educators who are interested in visual education. If the manufacturers knew what we wanted, I believe that it would be produced.
(12:-18:25)

Role of animated motion pictures

The application of animated drawings to the instructional film, a comparatively recent development, has met with widespread approval in educational circles, for by such means it is possible to show many things that can be shown in no other way. Of these films, it has been said: "The potentialities of this field are limitless for future development". (8:253) This point is further emphasized: "No other visual aid is so fertile in its possibilities...." (11:102)

While animated motion pictures may be used in nearly all branches of study, they seem to the writer especially applicable to the teaching of sheet-metal pattern drafting. This work is highly technical in that the completed pattern is composed of a series of processes difficult for the pupil to distinguish in the completed drawing. When these steps are animated in proper sequence in a motion picture, it is possible for the pupil to see their relationship. In this connection, Kruse states:

There is no question but that the use of well-made and carefully planned animated pictures represents a very important contribution to teaching aids. The animated picture can put into motion and into proper interrelationship otherwise invisible processes, and can even be used to elucidate abstract ideas and principles".*

Moreover, in many cases, even a study of the completed project does not help the pupil to identify the various processes of which its pattern is composed. Freeman says that "the animated diagram may give a better notion of structure and relationship than the sight of the object itself". (8:253)

No small amount of sheet-metal work is being taught by the copy method, i.e. the students copy a drawing of a given project, or trace a ready-made pattern. This method of teaching may result from the standards by which a school shop is judged. When shops can exhibit a large number of projects which show good workmanship, they are rated high in educational value. Little consideration is given by the judges as to how the projects were constructed. It is here that a deplorable weakness in the rating of the educational value of the school shop appears.

These animated films of sheet-metal pattern drafting are presented with a view to encouraging the reduc-

* Kruse, W. F., Manager of Films Division, Bell-Howell Company, (Letter to the writer, May 13, 1940)

tion of the stereotyped copy method used in many sheet-metal classes. There is little possibility that the films will add to the quality of the completed projects. However, it is reasonable to believe that the use of these films, together with the best efforts of the teacher in class demonstrations will give the students a better understanding of the processes involved in drafting patterns.

After the films for this study were completed, they were previewed by sixty members of the Seattle Industrial Arts Association. Immediately following the preview, a questionnaire was presented to each member of the group to record their reactions toward this type of visual aid. Of the sixty distributed, forty-eight questionnaires were checked and returned. This questionnaire is in two parts; one is considered in the pages that follow, and the other is discussed in the CONCLUSIONS.

The first part of the questionnaire is reproduced on the next two pages. The answers in percentages are given on page 6C, Table I. It will be noted that in the table, two columns have been added to provide space for recording percentages of unchecked questions and of qualified answers. On pages 7 and 8 will be found the list of items suggested by the Association for animation. Certain opinions are considered on page 9.

QUESTIONNAIRE ON ANIMATED MOTION PICTURES
FOR INDUSTRIAL ARTS

Your answers to the following items will be of considerable value in determining worth-while methods of using animated motion pictures in Industrial Arts subjects, and in evaluating such pictures as visual aids.

Please check the questions in accordance with the provisions made for that purpose on the right-hand side of the page.

- | | | |
|---|-----|----|
| 1. Do you find that a few students in most classes fail to grasp the important points in a regular classroom demonstration? | Yes | No |
| | Yes | No |
| 2. Do you think certain teaching units could be taught more effectively if animated motion pictures were used to supplement the teacher's best efforts? | Yes | No |
| 3. Do you believe the use of animated motion pictures would help overcome individual differences in pupil learning? | Yes | No |
| 4. Could the length of the demonstration possibly be reduced by using animated motion pictures of the learning units being taught? | Yes | No |
| 5. Would additional animated motion pictures of certain selected learning units in industrial arts be a worth-while contribution? | Yes | No |
| 6. Assuming that sheet-metal drafting and layout work is a difficult subject for pupils to grasp, would animated pictures help in presenting this unit? | Yes | No |
| 7. Is it your impression that students will gain more when animated motion pictures are used than when they are not used? | Yes | No |
| 8. Have you ever used a short film for the purpose of supplementing your demonstration? | Yes | No |

9. Would you use films of this type if they were available, with the other equipment necessary to show them? Yes No
10. In your opinion, would such films challenge pupils to greater accomplishment? Yes No

List below any teaching units in industrial arts which you think could be taught to better advantage by using animated motion pictures as a supplementary teaching device.

1. (These are compiled on pages 7 and 8)
- 2.
- 3.

TABLE I

COMPILATION OF ANSWERS TO QUESTIONNAIRE ON PAGE 6A
IN PERCENTAGES

Question number	Yes	No	Unanswered	Qualified
1	100	0	0	0
2	100	0	0	0
3	77	17	2	4
4	56	36	4	4
5	94	2	2	2
6	94	0	4	2
7	90	2	4	4
8	37	63	0	0
9	90	4	2	4
10	73	15	2	10

Units and Projects Recommended for Animation on Questionnaires

Wood turning

Sheet metal

Machine shop

Art metal

Combustion motors

Hydrostatics

Tool processes

Automobile units

Drawing units

Drafting techniques and methods

Woodworking techniques and methods

All shop projects

Safety instruction, and development of proper
attitudes toward safety

Development of desirable attitudes toward shop
maintenance

Repeating films where position and timing are
factors, as filing, sawing, etc.

Orthographic projection

Teaching of gears and cams

Related information

Techniques in all departments

Men working in industry showing good work habits,
and acquainting pupils with different types
of work in industry

Architectural drawing I

Mechanical movements

Wood finishing

Tool sharpening

Elementary drawing - layout and view finding

Correct use of mechanical drawing instruments

Use of woodworking tools, hand and power

Use of varnish brush

Marching formation for bands

Orthographic projection

Use of different scales

Sectional drawing

Mortise and tenon joints

How to sharpen a hook scraper

Boat drawing

Architecture

Use of such films to connect mathematics and
industrial arts

The opinions expressed in regard to questions one, two, six, seven, and ten are substantiated by Donald C. Doane, who writes as follows:

Students of lower I.Q.'s gain proportionately more from the film as compared with other methods than do students of higher I. Q.'s. This has been tested repeatedly, and a high degree of inverse correlation has been found between I. Q. and advantage gained from the film. This has been proved probably more significantly than any other conclusion reached regarding educational films. (6:-12:203)

The consensus of opinion on question four indicates that it is questionable whether the use of animated films would save any time in demonstrating the processes. However, since ninety-two per cent of the answers indicate that films would be used if available, it is evident that the present style of demonstration might be altered to admit their use.

The results of the questionnaire are in accord with some of the writer's aims for producing films of this type. Such favorable opinions on this type of visual aid by men interested and experienced in the field are most encouraging. The enthusiasm with which these films were received indicates that they may, in time, be a real contribution to the teaching of sheet-metal pattern drafting.

C. SELECTION OF UNITS FOR ANIMATION

Definitions of terms.

An understanding of trade analysis is invaluable for the purpose of breaking down a trade into small units and for constructing a course of study from the important elements of the trade. The present study does not require complete analysis of the trade of sheet-metal working, but it does require a knowledge of certain units included in that trade. These units are known as "teaching units" or "learning units". (18:30) They are classified under two main headings, "skills" (18:19) and "related information". (18:14) The units concerning skills are those which "You must know how to do"; those on information concern "what you should know", and "what you should be". (18:48-49)

Films may be divided into two groups, one dealing with skills, and the other with related information. George B. Cox classifies films for shop use into the following groups: "... (a) background and general information, and (b) teaching films covering specific subject matter". (4:29:43) Of these, he says: "The background films are available in considerably greater numbers than those designed for direct instruction". (4:-29:43) The units animated for this study are those attempt-

ing to show how to perform certain tasks in a course in sheet-metal work. Therefore, they would come under the classification of "direct teaching" and "specific subject matter". (4:-29:43)

Bases for selection

The production of animated educational films has not yet entered the field of sheet-metal work. After an extensive study of available animated films for instructional use, it was found there were none in sheet-metal work. Therefore, without information on experiments in this field, the selection of units for this study was left wholly to the decision of the writer.

In selecting these units, the following questions presented themselves and were carefully considered:

1. Is a motion picture for this unit highly desirable?
2. Can this unit be well represented in a motion picture?
3. Are these units used in a relatively large number of school metal shops?

In regard to question 1, it must be kept in mind that "only where this type of presentation would give a clearer concept than any other is the topic suitable for a motion picture lesson." (9:-13:5) The writer has been

working on the assumption that students presented with a complete drawing or pattern of a sheet-metal problem frequently have difficulty in understanding the processes involved in the construction. The suggested animated units would reduce such difficulty by presenting the drawing or pattern step-by-step and giving students an opportunity to see each process involved. The use of animated motion pictures is, therefore, highly desirable in teaching this type of work.

As for question 2, the writer used as his measuring-stick Doane's characteristics of a good instructional film, as follows:

1. Correlation with and integration into the usual course of study for subject and grade intended
2. Limitation to presentation of facts
3. Provisions for future activity; challenging future thought
4. Best possible degree of technical perfection
5. In general, limitation of length to at most one reel (7:-15:305-307)

The film produced for the units selected meets these qualifications. Consequently it is demonstrated that this material can be well represented in animated films.

In connection with question 3, it appeared to the writer that the units selected for experimental animated

films would contribute more if chosen from elementary or beginning sheet-metal projects rather than from advanced projects. There are more elementary than advanced courses in public high school sheet-metal shopwork. Consequently a relatively large number of shop teachers are concerned with problems of teaching elementary courses in sheet-metal-drafting. Many of these teachers have had training in elementary sheet-metal work, but few have had advanced training. There was also the possibility by means of a questionnaire to obtain from a group of such teachers ratings on the values of the animated films under discussion.

Animated films produced for this study

With the above points in mind, the projects and units listed below were chosen for animation. The films of these projects and units accompany this report.

<u>Projects</u>	<u>Units involved</u>
1. Tin cup (13:34-37)	Develop patterns for cylindrical objects
	Allow extra material for lock seam
	Allow extra material for wiring
	Allow extra material for burring

<u>Projects</u>	<u>Units involved</u>
2. Scoop (13:46-48)	Develop patterns for cylindrical objects cut off at an angle Allow extra material for lock seam Allow extra material for burring
3. Funnel (17:20-21)	Develop patterns for conical objects Allow extra material for wiring Allow extra material for lock seam Allow extra material for lap joint
4. Two-piece elbow (20:29-30)	Develop patterns for two-piece ninety-degree elbow Allow extra material for lock seam
5. T-pipe intersection of like diameters (20:27-29)	Develop patterns for T-pipe intersection Allow extra material for lock seam

In addition to the above units and projects constructed into animated films, the writer has produced in animation the following list of geometry problems, representing some of the essentials needed in certain parts of sheet-metal pattern drafting.

1. Parts of circle
2. How to construct pentagon from given side
3. How to construct pentagon within circle

4. How to construct hexagon within circle

5. How to construct octagon within circle

These films constructed on geometry problems were previewed by the Mathematics Department of the Seattle Public Schools, and as a result, a copy of each film was added to the general film library.

CHAPTER II

HISTORY OF EDUCATIONAL ANIMATED MOTION PICTURES

Animated motion pictures for educational purposes are a comparatively recent development in the field of visual education. Indeed, they have been produced on a commercial scale only during the last decade. (5:352) It has been apparent to many educators that such films fill a unique need in the teaching process; and although they are, as yet, far less numerous than educational films of other types, their value as a visual aid is generally accepted. (8:253)

In spite of their recent development, the history of animated educational motion pictures is a lengthy one. It is, of necessity, intermingled with much of the history of the experimental work from which cinematography developed. (8:4) In order to present a clear picture of the development of animated educational films, the highlights in the history of motion pictures are presented in the following pages. This brief historical account begins with the early efforts at photography, outlines some of the more important experiments which led to improvements in photographic materials and techniques, and, finally, describes some of the techniques that have

been used in the development of the educational animated film as we know it today.

A. EARLY EXPERIMENTAL WORK

The coming of the motion picture can be attributed to the age-old wish for the re-creation of events. Aristotle, in Greece, was the first to observe that a square hole in a shutter illuminated by the sun cast a circular spot of light against the wall of a darkened room. Doubtless, many curious scholars in the succeeding centuries saw various puzzling phenomena of light and images which after years of research finally led to the camera. Leone Battista Alberti, an artist of Florence during the Italian Renaissance, used a prismatic arrangement by which a reduced image of an object could be cast on a drawing board and thus made convenient for tracing.

(16:3)

Leonardo da Vinci, born in Florence in 1452, further contributed toward the motion picture by observing that through a small circular hole in a shutter of a darkened room the image cast on the opposite wall showed in detail the building or landscape outside. Terry Ramsaye says:

(16:4)

This room was in reality the camera obscura, used by artists for centuries after, and it was indeed, too, the camera of today, lacking yet only the sensitized film or plate. If Leonardo had had the chemical means of coating the glass plate of his experiments in perspective and catching thereon the image he found on the wall of his room, he would have had photography, which, in a nameless, unconscious way, he was seeking.

At a Jesuit College in 1640, about a century and a half after Leonardo's camera obscura, the first preview of the "magic lantern" was given to a group of nobles and wealthy citizens of Rome. (16:6) Athanasius Kircher developed the lantern. With crudely painted slides, he presented to his audience a successful demonstration. The invention of the magic lantern should be credited to an unknown German from the ancient community of Geiss. (16:6). The lantern marked the first important projection of a picture to an audience.

In 1646 Kircher published "The Great Art of Light and Shade", in which he described the principles of the magic lantern. (16:6-7) His lantern had a lamp, a reflector, and a lens, the fundamentals of our present-day lantern. Kircher did some experimental work with a revolving drum on which pictures were placed, the drum revolving inside the lantern. It was work which almost brought motion pictures to the world.

B. FIRST MOTION PICTURE MACHINE

It should be noted that although there was steady improvement in the projection lantern, progress toward motion pictures was slow. The early lanterns were greatly improved by the lens makers and, as their art advanced, the quality of the lanterns improved until finally it was possible to satisfactorily project still pictures onto a wall. However it was not until about two hundred years after Athanasius Kircher's lantern show that scientific investigations on the principles of motion were begun. These investigations led to the present-day motion picture.

In foreign countries

Little progress toward the development of motion pictures was made until 1832, when the first motion picture machines appeared in Ghent and Vienna. Two scientists, Plateau and Stamfer, at almost the same time but independently of each other, constructed the first devices for showing pictures in simulated motion. (16:12-14) Their machines were identical in all respects. Both placed pictures of phases of motion on the rim of a disc, and viewed them through slits in another disc which was blackened on the viewing side and revolved on the same axis as the picture disc. When the discs were twirled

and the eye placed in the proper position, the pictures appeared in a continuous series. This development came a year after Michael Faraday published a book on his observations of motion. Stamfer named his machine the Stroboscope, and Plateau called his the Phenakistoscope.

Twenty years later, in 1853, a soldier in the Austrian army, Lieutenant Baron Franz von Uchatius, combined the magic lantern produced by Kircher and the stroboscopic discs of Stamfer, and projected the pictures on the wall. (16:14)

Again the progress of motion pictures stood still, awaiting the development of photochemistry. Some experimental work in this field had been done before 1800, but without important results. The process of producing records by the action of light was discovered in 1802 by an Englishman, Tom Wedgewood. (8:4) His negatives, however, were not permanent and soon faded.

The next great discovery was made in 1819, when Sir John Herschel found that hypo-sulphite of sodium would make a negative permanent. (16:15) It had been known that certain salts of silver coated on a surface and exposed to the sun gave a pattern of the object held over it as a stencil. The difficulty was that the coated surface faded, and the pattern was soon lost. Herschel's discovery was important because it showed the negative

could be treated so as to remove the unaffected silver salts and leave a permanent picture. This chemical, known as "hypo", led to the photographer's term "fixing".

In the United States

In 1860 Coleman Sellers, of Philadelphia, did the first experimental work with motion pictures in the United States. (16:16) Sellers actually crudely constructed animated motion pictures. He did not photograph motion because he had no device fast enough, physically or chemically, but he built up, step by step, a synthetic cycle of movements by representative instants of motion. This achievement is the basis of our animated motion picture. (8:6) Sellers constructed his pictures stereoscopically with an ordinary twin-lensed camera. The pictures were mounted on a sort of paddle wheel. By turning the wheel at the proper speed, an illusion of motion resulted. Sellers named his machine the Kinematoscope. It is from this word that many derivatives are today common terms in the motion picture field.

In 1870, Henry Renno Heyl, of Philadelphia, added valuable improvements to Seller's Kinematoscope. (16:18-20) Heyl produced all the mechanical effects necessary to project pictures on a screen, an important development, his being the first machine of the type. (16:50)

Shortly after this, the attention of experimenters in photography was directed to California where events leading to what is called "the Muybridge myth" (16:21) were taking place. These events concerned a wager made by Governor Leland Stanford concerning his race horses. He had always maintained that at various gaits, a horse at full speed had all four feet off the ground at once; but he had never been able to prove it. Casting about in desperation, he finally employed an English photographer, Edward Muybridge, known locally for his photographs for the U. S. Coast Survey, and then employed by a local photographic establishment, to try for pictures showing the gait of a horse. Muybridge made numerous and costly attempts to prove the Governor's point. He finally succeeded in taking a picture that showed a horse with all his feet off the ground. (16:24)

This incident gave impetus to his studies in the analysis of movement, and in 1872 he made his famous study of the Palo Alto horse-race. He placed twenty-four cameras at the edge of the race track, "conveniently close together", (8:7) with a fine thread tied to the shutter of each and stretched across the track so that the running horse would break the string and thus take his own picture. The results were surprisingly good and created such enthusiasm that Muybridge pursued with

increased vigor his experiments of pictured motion (8:7)

Muybridge has been erroneously credited with originating the motion picture. Much of the credit should really go to John D. Isaacs, former Chief Engineer for the Southern Pacific Railroad, and to Jean Louis Meissonier, a French painter. Both men constructed devices that helped to make Muybridge famous. (16:35-41) In collaboration with Meissonier, Muybridge invented a machine called the Zoopraxoscope, which projected "moving pictures" on a screen. This machine was a large glass disc with reproductions of photographs of moving objects taken with different cameras set along its margin. The disc revolved, and as the photographs were projected, they gave the impression of motion. (8:7)

Later, Muybridge was invited to become a member of the staff of the University of Pennsylvania, which offered facilities for continuing his experiments. Thus he became a "photographer to a University instead of a race track." (16:43) After his University appointment, he became widely known and attended many scientific gatherings. He met Coleman Sellers and Henry Renno Heyl at Franklin Institute, a noted scientific society, and later made the acquaintance of Edison, who is said to have commented on his visit as follows:

Muybridge came to my laboratory to show me some pictures of a horse in motion that he had taken in California. But nothing was said about the phonograph. (16:44)

Muybridge continued his work at the University of Pennsylvania for about ten years. In 1893, the university entered an exhibit of his pictures at Zoopraxographical Hall at the Columbian Exposition in Chicago. This exhibit included a showing of pictures on the Zoopraxoscope, which, nearly ten years after its introduction in Paris, was almost identical with the machine that he and Meissonier had used. Thus, in ten years, he had made practically no advance, and he contributed nothing to the progress of the screen of today. (16:44)

C. IMPROVEMENTS IN MATERIALS AND EQUIPMENT

It was at this stage in the development of the motion picture that scientists and business men foresaw great possibilities. They spared no effort to improve what had already been done, and as a result, many innovations in equipment and techniques appeared. Many of these improvements resulted from the earlier work of Edison and his associates who had been experimenting with motion pictures for several years. Their work gave impetus to the already expanding field, and laid the groundwork for our present-day moving picture industry.

It is interesting to note that in his work on motion pictures Edison utilized some ideas he had incorporated into his phonograph. It will be recalled that in the phonograph he used cylindrical records. It was on one of these that he applied photographic emulsion, and by the use of a small camera, recorded motion pictures on the cylinder. He then constructed his projector so that it showed forty pictures per second, a speed which gave the illusion of smooth motion. However, other research workers and commercial groups found later that sixteen pictures per second were satisfactory. Edison was not altogether pleased with this discovery, for he looked upon the change from forty frames to sixteen frames per second as a commercial degradation of the picture.

(16:51-56)

Development of flexible film

In spite of the fact that Edison's cylindrical film was a scientific advance, it did not prove altogether satisfactory. Consequently, one of the pressing needs was to find a suitable composition on which to spread the photographic emulsion. (16:56) Celluloid sheets were experimented with, but they were heavy and in too short lengths. This material, however was a vast improvement over the breakable one previously used. In these

experiments, Edison employed thirty-five millimeter film, the same width now used for commercial pictures. Even the number of perforations beside each frame is the same today as in Edison's experiments. (19:68)

In 1889 George Eastman entered the motion picture field. (16:61) With the two great minds of Edison and Eastman concentrating on the problem of motion pictures, the perfected equipment of this great industry was already in the making. After struggling with the problem of producing a tough, transparent, and flexible material suitable for the foundation on which to spread the photographic emulsion, Eastman, in 1889, made such a discovery. (16:62-63) The material he developed resulted from drying a varnish composed of wood alcohol and "soluble cotton". When spread on a glass plate, this produced the substance needed for motion picture film. The film was made in one-hundred-foot lengths.

Improvements in projection

After a suitable film was discovered, the next problem confronting the experimenters was the construction of a lantern to project the motion pictures on a screen. Edison and his assistant, William Kennedy Laurie Dickson, made extensive experiments to this end. It is interesting to note that Edison, throughout all his motion

picture efforts, considered the phonograph and the motion picture inseparable. He wanted motion pictures to give the phonograph new significance. He had in mind the invention of a combination apparatus for seeing and hearing, and was, in reality, working toward the talking picture of today.

The year 1889 marked the first successful results of Edison's and Dickson's experiments in the synchronization of moving pictures with sound. During that year, Edison spent some time in Europe, and returned to find that Dickson had developed a projector synchronized with a phonograph record. (16:65) Terry Ramsaye quotes from a book written by Mr. and Mrs. Dickson and published in 1895 as follows:

.....The crowning point of realism was attained on the occasion of Mr. Edison's return from the Paris Exposition of 1889, when Mr. Dickson himself stepped out on the screen, raised his hat and smiled, while uttering the words of greeting, 'Good morning, Mr. Edison, glad to see you back. I hope you are satisfied with the kineto-phonograph'. (16:66)

Although Dickson had produced a projector, greater refinement was needed before the machine was ready for commercial use. The possibilities of projected pictures were now clear, and many other men became interested in the work of the two scientists. Indeed interest became so great, that within a few years, there was a war of

patent litigation over projected pictures. Since Edison did not foresee the tremendous importance of the motion picture industry, he did not sufficiently defend the numerous law suits to retain control of his invention. Eventually, the motion picture industry was taken out of his hands. However, Dickson always maintained, even thirty years after he previewed for Edison a synchronized film with a phonograph record, that he secured projected pictures in 1888 in the Edison laboratories by himself. (16:75-78)

In 1889, the same year in which Dickson successfully combined projection and sound in Edison's laboratory, Edison built a projective repeating device which he named Kinetoscope Number One. It operated with fifty-foot lengths of film on a bank of spools, and was in reality, the forerunner of the modern reel. (16:71-72) It is said his first thought was that the principal value of the Kinetoscope would be "the contribution which it could make to education". (14:-19:107)

With the coming of the intermittent film projector, invented by C. Francis Jenkins, the stage was set for a great expansion of the motion picture industry. In 1895 Jenkins applied for a patent on his machine. (16:142-144) By 1900, the world had satisfactory material for motion picture film, a camera to produce the pictures on a length of film, and a projector to cast the picture on a

screen. The material and equipment were ready for large-scale commercialization.

Improvements in the camera

Cameras, also, were brought up-to-date in the last decade of the nineteenth century by improvements which were a direct outgrowth of Eastman's development of flexible film. Again, Edison and Dickson experimented successfully, and designed a camera which had intermittent motion, and at the same time, held a supply of film. (16:71)

In Europe during this same period, experiments with cameras, similar to the work being done in this country, were also being made. In some instances, European scientists were slightly in advance of American developments. Robert W. Paul, of London, constructed a new camera with intermittent motion. This machine was similar to that made by Edison and Dickson for producing films used in the famous peep shows so popular at the end of the nineteenth century. (16:147-149)

Further improvements in camera construction and design took place rapidly. However, since many of these are not of immediate concern in this study, they are not discussed here. It should be noted, however, that in 1923, the Eastman Kodak Company produced a camera which gave great impetus to the use of motion pictures in the

schools. This was the sixteen-millimeter moving-picture camera, which, because it could be operated at a cost far below that of other cameras on the market, greatly stimulated the production of moving pictures for educational purposes. (5:325) In 1927-1928 Eastman produced twenty films, and started experimenting with them as visual aids. They proved so successful that in the latter part of 1928 Eastman began commercial production of sixteen-millimeter films for educational use. (5:327)

D. EDUCATIONAL ANIMATED MOTION PICTURES

The animated motion picture of today is a direct outgrowth of the earliest experiments in motion pictures. (8:6) Throughout the development of motion picture photography, many experiments were conducted on the basis of taking one picture at a time, with some degree of action recorded in each picture, to produce the illusion of motion when at the proper speed such pictures were projected in series on a screen.

Animated films in the making

The following brief history of the development of educational animated films depicts the changes and improvements made in this branch of cinematography. The earliest animated drawings were invariably line drawings,

black on a white background, with movement created by adding to each line. These drawings were "jumpy", and, in projection, were unsatisfactory because the light background diffused and weakened the black lines. Next came the reverse, white lines on a black background, which proved more satisfactory. The next development was the production of animation by the scratch-off process. This consisted of starting with the last step in the animation and running the negative through the camera in reverse, scratching off a bit of the light between each exposure. With the advent of the use of celluloid overlays, more intricate work was done, in both line and wash drawings by either the additive or the scratchoff technique. The use of the air brush contributed to the artistry of such animation. Another step was the use of technical models which could be moved in stop-motion fashion between each exposure. At present, a combination of all these techniques is possible.*

So far as can be ascertained, the first use of animated pictures in education occurred in 1906. In that year, Mr. J. Stuart Blackton used animated pictures, one-frame-at-a-time, in giving chalk talks.** Numerous experiments in this field followed, but not until more

* Brill, James A. In correspondence with the writer of this study, May, 8, 1940. Director of Prod., Erpi Class. Films, Inc.

** Kruse, W. F., Mgr. Films Div., Bell-Howell Co.; In correspondence with the writer, May 18, 1940.

than twenty years later did educational animated films, as such, reach a degree of perfection to encourage their use.

Specialized functions of animated films

The number of animated films for instructional use is limited, and of these few are entirely animated. Most of them deal with the sciences and are designed to show phenomena which cannot be shown in any other way. Two companies which have done admirable pioneer work in this field are the Erpi Classroom Films, Incorporated, and the Bray Pictures Corporation. James A. Brill,* Director of Production of the Erpi Classroom Films, Inc., says:

There are very few instructional films which are wholly animated. About nine years ago, we produced one called The Play of the Imagination in Geometry. Other of our films, such as Sound Waves, Acoustics, Electrochemistry, Electrostatics, Body Defenses Against Disease, and many others in the various sciences, employ animated cartoon or technical animation wherever this is needed..... If a phenomenon cannot be shown by photographic means, we resort to animation.

Selected list of educational animated films

Thus it is seen that, although much admirable work has been done in the field of educational animated films, there still are great possibilities for work in this

* Brill, James A. Correspondence.

type of visual education. In this connection, a selected list of educational films, partly or wholly animated, is submitted in the appendix. The films named in this compilation have been recommended for their high teaching values by educational directors of the companies producing them, such recommendations being based on the reactions of instructors who have used them.

Even a cursory consideration of this list reveals that, at present, animated films are applied to only a limited number of fields of learning, and in those fields, only to the clarification of abstract conceptions. It is further evident that the field of industrial arts has not been included for clarification through the use of animated films. Moreover, after an extensive study of the available supply of animated educational motion pictures, it has been found that producers have not applied animated films to sheet-metal drafting. Hence the need for the present study is obvious.

CHAPTER III

CONSTRUCTION OF SELECTED UNITS INTO ANIMATED FILM

Much has been written about the production of amateur animated films for entertainment purposes, but there is little source material explaining the construction of animated educational motion pictures. In connection with the research conducted in this study, requests for information on both the production and the use of animated films for educational purposes were sent to thirty-five organizations dealing in the production and distribution of such pictures. Several educational departments and commercial companies specializing in motion pictures were included. The contributions of these organizations were made in letters to the author, and certain information applicable to this study is cited in this report. The letters are acknowledged in Appendix I.

The explanation which follows is naturally almost entirely a review of the writer's own experiences in producing the films on which this study is based. It includes a description of the processes and materials used, together with advisable recommendations.

A. TYPE OF ANIMATION

The sheet-metal problems which were animated for this study are of the line-drawing type. Therefore, the explanation dealing with equipment and method used is restricted to that type of animation.

B. FACTORS INVOLVED IN PRODUCING ANIMATED FILMS

The problem of constructing animated motion pictures is a highly technical one, involving definite factors. Before attempting to create animated films, the producer must have a working knowledge of cinematography. Photography and drawing are so interdependent that a description of one is inadequate without the other. It is likewise necessary that the animation worker have a knowledge of the motion picture camera if he is to utilize it to best advantage in recording animation. The fundamentals of animated cinematography include the following:

1. Mechanics of motion picture camera
2. Type of film
3. Lighting
4. Exposure
5. Testing for correct exposure
6. Width of lines
7. Focusing
8. Determining field

9. Basic equipment
10. Preparing drawing
11. Speed of animation
12. Titling

Each of the above factors is described in the following pages.

Mechanics of motion picture camera

The movie camera of today (See Fig. I) is designed to record small pictures on a ribbon of film, (1:18-21). When this film is projected by means of the proper equipment, an illusion of motion appears on the screen. Cameras are available in the following film widths: eight millimeters, nine and one-half millimeters, sixteen millimeters, and thirty-five millimeters, the theatrical type. In recent years, the sixteen-millimeter type has become standard for most educational purposes.

The camera lens directs the light on the sensitive surface of the film through the aperture; the shutter cuts off light when the claws pull the film through the gate, and permits light to reach the film when the latter is motionless. The film and the special machinery which moves it are inside the case of the camera, which is impervious to light.

The camera used for animation work should be equipped with a single-frame exposure device. The writer's experi-

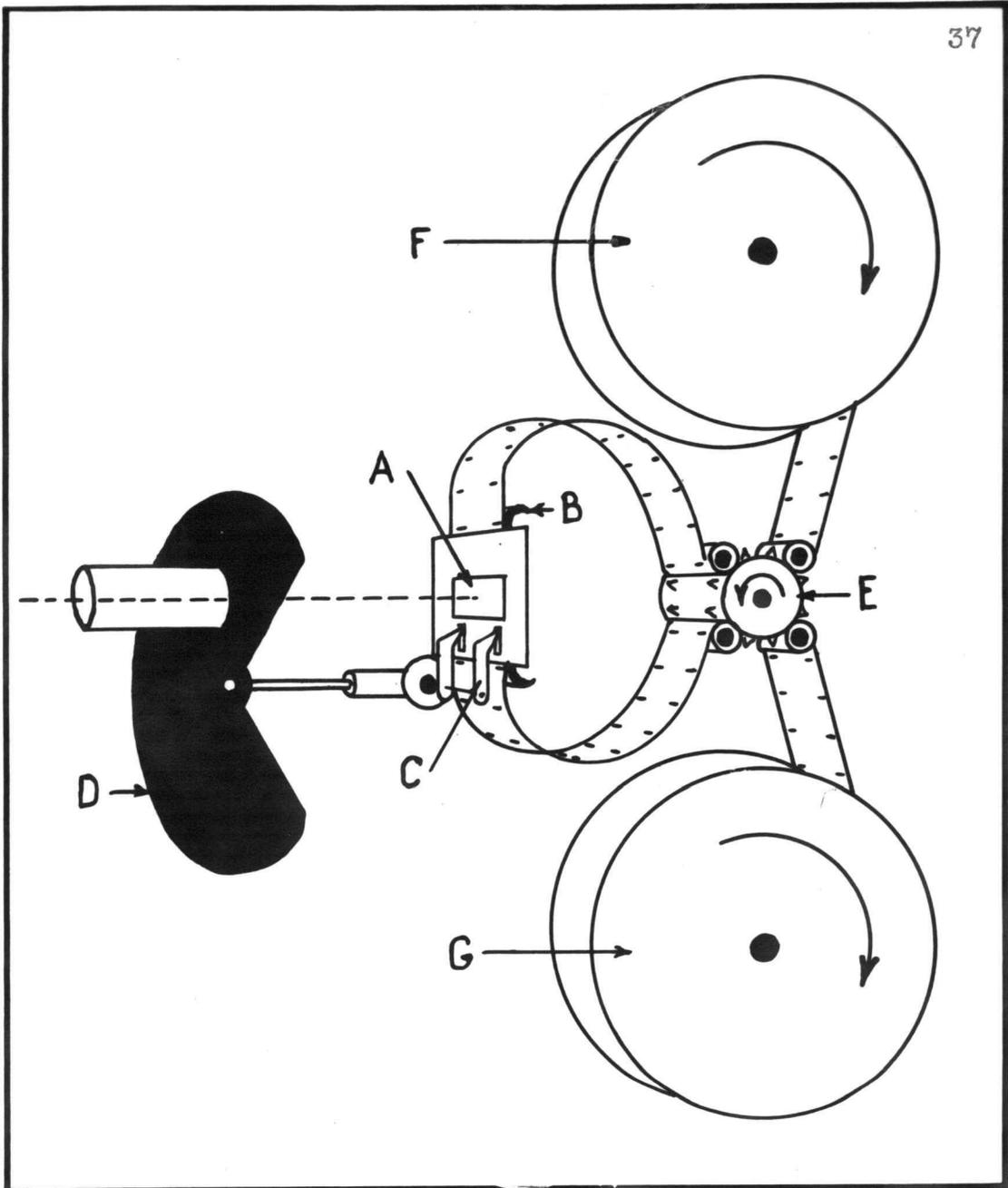


FIGURE 1

ESSENTIAL PARTS OF A MOVIE CAMERA

A. APERTURE

D. SHUTTER

B. GATE

E. SPROCKET

C. CLAW

F. SUPPLY REEL

G. TAKEUP REEL

ment was carried on first, with a Victor, and later with a Bell-Howell 16-millimeter camera. The Victor was unsatisfactory because it did not have a single-frame attachment, and because it was a used camera in need of repair. Since it did not function properly, various frames of the film were either over or under-exposed. Consequently five-hundred feet of the animated drawings constructed were unsatisfactory and had to be remade. At this time, through the efforts of Professors Eby and Welch, a Bell-Howell camera was secured from the Stockton Junior College. After preliminary testing, this camera, which had a single-frame attachment, proved highly satisfactory.

Type of film

Since this study was conducted with positive film, a discussion of other types of film is omitted. For the purpose for which these animated films are intended, positive film proved very satisfactory. First, the low cost of positive film makes it especially suitable for experimental purposes. Second, excellent contrasts between black and white may be produced with this kind of film. Third, copies of the original film may be satisfactorily reproduced. Two copies have been printed from the original films made for this study; one is in the

film library at Stockton Junior College, and the other is in the film library of the Seattle Public Schools.

Positive film is often called the "color-blind" type. Most of this film is used in printing negatives. It corresponds to the printing paper used in reproducing snapshots. All positive movie film has about the same degree of color-blindness, and because it has high contrast values, is especially suited to making animated pictures of line drawings. A black background with white lines makes excellent contrast for such drawings.

Positive film is easily handled. It is not sensitive to red light, and can be handled in even a reasonably bright orange-colored light. It may be secured either on spools or in a laboratory package, in which case it is supplied in cans without spools or leaders. For this experiment, the writer used laboratory packages. The laboratory package may be placed directly in the camera if a small wooden spool is placed over the shaft holding the standard spool. This wooden spool should be large enough to hold the roll of film so that it will feed freely through the sprocket and gate. The take-up spool must be the regulation one, since the power from the camera is used in winding up the exposed film. Before sending the film to be processed, it should be taken off the metal spool, since the latter might easily be lost

in the processing laboratory.

The emulsion on positive film is thinner than that on films made for reversal processing. When positive film and reversal film are spliced together, the focus sometimes changes while the film is being projected. This is caused partly by the relative thinness of the positive film, and partly because it curls somewhat differently than the reversal film.

Lighting

Constant light values should be used for all line-drawing animations. In providing illumination for this type of cinematography, two considerations are involved: (1) there must be sufficient light on the drawing to provide a satisfactory exposure, and (2) the illumination over the entire drawing must be evenly distributed. It was found by experimentation that two Number Two photo-flood lamps provide sufficient light. Each lamp was located in a reflector two feet above an end of the drawing. Silk light diffusion filters were used on the reflectors to insure an even diffusion of light over the drawing. It should be noted here, however, that care must be exercised in the use of filters. Only a moderate amount of diffusion is needed for line-drawing animations, since these must have clean, clear lines that contrast

sharply with the background. Too much diffusion of light results in a film that appears foggy on the screen.

Both lamps should be controlled with a single hand switch located conveniently on the drawing table, or on the floor for foot control. Either system satisfactorily permits the experimenter to turn the lights on and off quickly and easily.

Exposure

Regardless of the source of light, the correct exposure of the film must be determined. Any deviation from the proper exposure in constructing animated films must be carefully avoided. Since the ideal exposure gives a clear contrast between the lines and the background, any change in contrasts in the projected film naturally detracts from the students' attention when the pictures are shown on the screen.

Three conditions may develop in the exposure of the film. The diaphragm, or aperture, may be set to admit varying amounts of light. If the opening is too large, the film will be over-exposed. This results in a very dark picture. When the opening is too small, the film will be under-exposed, and the pictures will be light and pale. The third condition is the ideal exposure which gives the desired light and dark contrasts in the film.

Testing for correct exposure

Testing films for the correct exposure is a factor of utmost importance in making animated moving pictures. It is essential that all factors involved in this phase of the photography be correct. The necessity of careful testing is emphasized by Carl D. Clark as follows:

It is always best, especially for the beginner, to make tests from time to time by animating drawings under the camera and projecting them after development and printing to see if the action runs smoothly. Even the well-trained and experienced professional animator occasionally feels sufficiently uncertain about his ultimate results to make test drawings and exposures. (3:-6:12)

In determining the proper diaphragm setting on which to base the exposure tests, any of several methods may be used. However, since animated film is always exposed under artificial light and in a laboratory, the use of a photo-electric exposure meter is recommended. Several types of meters are available, most of them adjustable for different sensitivities of film. It is necessary to know the sensitivity of the positive film that is to be used. This information can usually be obtained from the manufacturers, but since film manufacturers occasionally change the speed of the film, it is highly important to obtain the latest information regarding its sensitivity. The manufacturers of meters supply instructions for using and adjusting their product; consequently nothing is to

be gained by presenting in this report a discussion of the workings and adjustments of meters.

There is only one way to be absolutely certain that the exposure is correct, that is, by exposing short lengths of film, each with a different diaphragm opening. These lengths must be developed in the same strength developer that is used to develop the film proper. The developed test film must be projected on a screen to determine which diaphragm opening should be used to produce the desired contrasts in lights and darks.

The exposure required for single frames may not be the same as that needed for a series of frames or a "run". It is here, especially, that the animator must be thoroughly familiar with the particular camera he is using. All motion picture cameras have a governor to regulate the number of frames per second, and some cameras have adjustments on the governor to enable the operator to change the rate of frames per second. Instructions from some camera manufacturers recommend setting the camera at half-speed, eight frames per second, when single frames are being exposed. The reason for this is that the mechanism of the camera is operated by a spring, and when single-frame exposures are being made, there is little opportunity for the spring to transmit the power necessary to operate the mechanism at the required speed. In such cases, it lacks the inertia to bring the governor

into action. Another factor to be considered here is the tension of the spring. A spring fully wound will exert more force on the mechanism than one only partially wound. Therefore, to be assured of uniform speed of single-frame exposures, the spring must be wound frequently enough to keep a uniform tension during exposures.

From the above discussion, it is seen that when the diaphragm setting is the same, there is a discrepancy between single-frame exposures and exposures of runs. Therefore a very careful test should be made to determine the variation between these two types of exposure when the pictures are projected on a screen. With the first camera used in this experiment, there was a great difference in the appearance of runs and single-frame exposures, and it was necessary to set the diaphragm specially for exposing single frames and then to test it for exposing runs. With the Bell-Howell model 70DA, the variation was slight, and it was found by testing that if the diaphragm was set half-way between the correct exposure for single frames and for runs, very little change in density was apparent when the pictures were projected on the screen. This eliminated the necessity of resetting the diaphragm each time a change between single frames and runs occurred, a great advantage to the animator. It was found by testing, also, that with the same diaphragm setting the Bell-Howell could be operated at the normal speed of sixteen

frames per second in exposing both single frames and runs. This emphasizes the necessity for testing carefully both single-frame exposures and exposures of runs.

During the exposure tests, it was discovered that the amount of exposure needed for the animations differed from the amount required for the photographing of the main titles, and that there were variations, also, in the light requirements of the various titles. These differences occurred because of variations in the amount of light reflection from the letters and the background. It will be recalled that the animated drawings were made on a white background with black lines. The main-heading title of each unit, however, was made with white letters on a black background. Also, the amount of light reflected from one title was not necessarily that reflected by others, since the number of white letters used in each title was not the same. Consequently in each title photographed, although the exposure of the actual animations remained nearly constant, a new exposure was necessary to produce the correct contrast between the letters and the background. Frederick G. Beach, Technical Consultant of the Amateur Cinema League, Incorporated, says:

There is only one correct exposure for title work, and there are no compromises. In order to have perfect results in the finished title, the blacks must be strong and deep, while the

whites must be clear and unveiled. There is no universal rule for title exposure, and the most satisfactory way to find what is right, is by testing. (2:11)

In addition, tests for exposure should include a check on light diffusion and on the size and location of the field. The latter will determine the size of the drawing which may be photographed. The size of the lines and the sample animations should also be included in the trial tests.

Width of lines to be used

The size of the lines on the animated drawings should be determined by testing before the main work is begun. For the test film, lines of several sizes may be photographed, and it is desirable to use several kinds of materials for drawing the lines in order to see which lines photograph best. The projected test film will show the most satisfactory line to use for the drawings. In this experiment, India ink was found to give the most clear-cut line of all the materials used. In projection, pencil and crayola give the edges of the lines a feathery appearance. The ink may be used either with a speedball pen or with a brush, and the main lines, such as the object lines, should be about three-sixteenths of an inch wide. Less important lines are drawn with a smaller pen or brush. It is desirable to have lines of several sizes on

a single drawing so as to conform with the standard practices of the drafting room.

Focusing

Good animated drawings shown on a screen must have clean-cut lines. To achieve this, the focusing mechanism of the camera must be set at the proper place. Most cameras are manufactured with a ground glass focusing mechanism through which the operator may observe the image of the drawing on a ground glass. Once the correct focus for animated work is found, there is no need for change, unless for any reason the camera-holding device is changed. If the distance from the drawing to the lens is recorded and the correct focus location on the camera is noted, it should easily be possible to reset the equipment. The tests of the film will indicate how sharply the drawing is in focus.

Determining the field

It is very important to know the exact limits of the field so that the drawings will fall precisely within it. Because of the close attention the worker must give to it, the camera must be rather close to the drawing. In this experiment, the one-inch lens was located three feet above the drawing. Every camera has a view finder,

through which the operator locates the field to be photographed. Since the camera lens is close to the field, there is a slight discrepancy due to "parallax", between the field as seen through the view finder and the one which will be photographed. Some cameras have a parallax view finder which is reasonably accurate, but which, nevertheless, should be tested for accuracy before the final film is made.

A simple method of determining the location of the field is to locate it as nearly as possible through the finder; then place a mark in the center of the field, Fig. 2. From this mark, graduate the distance in equal divisions to each side of the field, and continue the graduations beyond the view-finder's field. When the test film is projected, the exact size and location of the field may be found by watching the location of the graduations in relation to the edges of the projected picture.

Basic equipment

The material being animated is the factor which determines the equipment necessary to produce the film. Certain basic equipment is necessary; this includes the camera, the film, the animation table, the drawing board, the floodlights, and the camera stand.

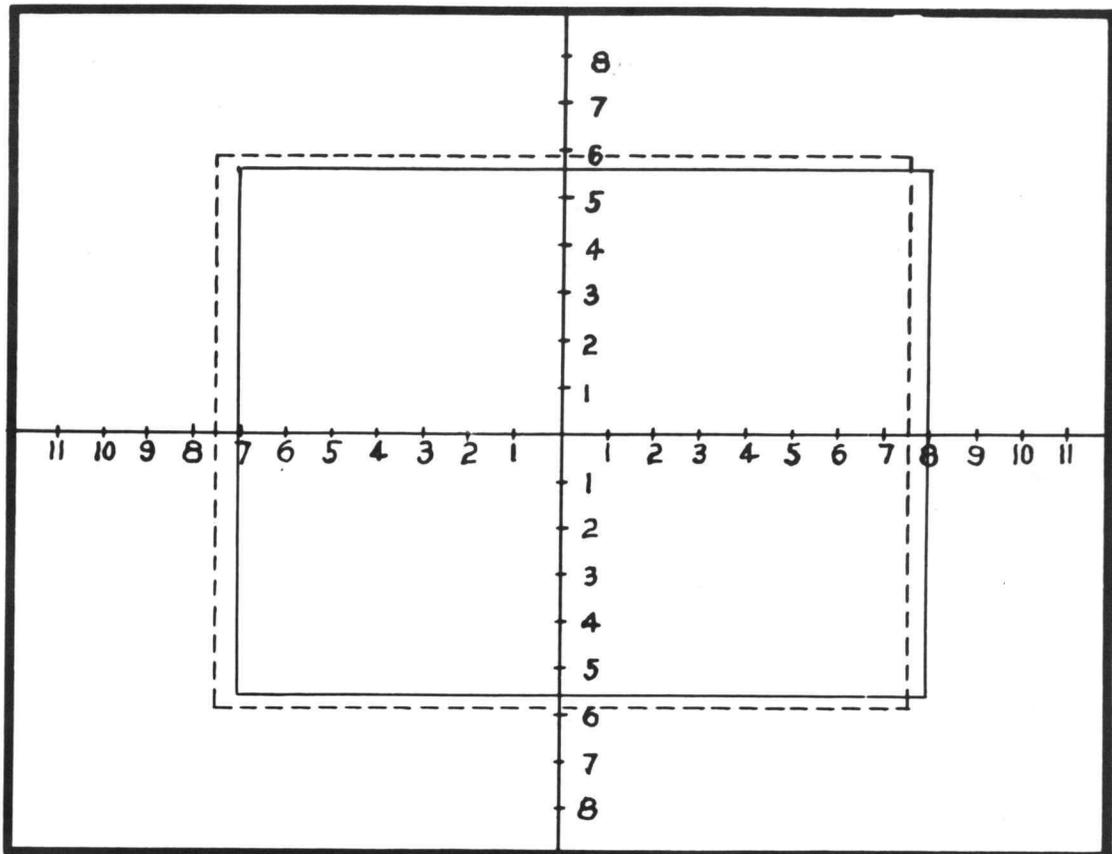


FIGURE 2

CHART FOR LOCATING THE MAXIMUM FIELD

Legend: LIMITS OF FIELD SEEN THROUGH VIEWFINDER -----

LIMITS OF FIELD DETERMINED BY TESTS _____

Other equipment used will depend upon the imagination and the inventive ability of the producer.

Since the films in this study are intended for use in both the drafting room and the sheet-metal shop, the accepted principles of the drafting room have been incorporated into the mechanics of their production. To show the relation of the instruments to the drawing, the drawing instruments used in this animation work were removed with each movement of line produced. The use of transparent equipment, such as angles and French curves, must be avoided; such instruments must be black to provide the correct contrast in density on the screen. An improvement in the films produced would have been the use of a black compass instead of the standard metal compass. The paper used for animations should be good grade white drawing paper.

Preparing the drawing

In preparing the drawing of the project, it is necessary to check the method of construction with that of several accepted authorities in the field and then use the one conforming as nearly as possible to the methods most commonly used. Although there are differences in the methods used in the classroom, and also in those employed in professional sheetmetal shops, the fundamentals

are similar in most cases, except when there are several methods of arriving at the same result. Many professionals use short-cut methods, but as nearly as possible, the films produced in this study were patterned after methods used in classrooms in teaching certain fundamental principles.

The drawing should be made with a hard lead drawing pencil and should be within the field covered by the camera. The scale should permit the largest possible drawing within the given field. The spacing of lines must be planned to take into consideration the fact that the main object lines are three-sixteenths of an inch wide. Any problem which calls for fine lines very close together must be presented in such a scale that the lines can be spaced far enough apart to accommodate the width of line required to produce the animation.

Speed of animation

The action of the animation is controlled by the distance through which the lines progress on each frame of the film. The general rule for producing smooth animation is that the action should not progress more than one-eighth of an inch per frame. There are forty frames in each foot of sixteen-millimeter film. Since the standard speed at which silent films are made and projected is sixteen frames per second, a moment's

calculation shows that it takes a trifle over four minutes for the four thousand frames in one hundred feet of film to pass the aperture of the camera or the projector. Therefore, to produce smooth animation at the rate of two inches per second, it is necessary to make the motion progress one-eighth of an inch for each frame of film exposed.

The above rule should not be followed at all times, however. In some cases, it should be varied because of certain characteristics in the problem being animated. For example, if a part of the drawing is complicated and highly technical, the action should be slowed sufficiently to allow the audience time to grasp the importance of the principle being animated. If, on the other hand, the drawing is simple and elementary, it is advisable to speed up the animation. Through the tests made in this experiment, it has been found highly desirable to analyze the complete drawing into the various movements to be shown in the animation. This is a means of regulating the speed of animation according to the capabilities of the pupils using the film.

In most animated films of this type it is desirable to expose two or three feet of film showing the beginning step before the action begins. This serves to orient the

pupils. This procedure should be followed, also, wherever a line makes an angle, for it is essential to provide time periods in which the pupils' minds can catch up with the progress of the animation. There is no known rule to be followed by the producer as to the exact amount of time which should be allowed to elapse at the important changes in the animation. Experience and knowledge of the students' difficulties to grasp the principles shown, together with the smoothness of the animation, are the essential factors which determine the timing of the animation.

In addition to the above-mentioned time periods during which there is no action on the screen, other devices to avoid possible misunderstanding and confusion were used. To help the students' eyes follow the progress of the animation, arrows pointing to the important features of the drawing were incorporated into the animation. The arrows also served to emphasize certain steps in sheet-metal-pattern drafting. Another pupil aid is the use of the metal letter Q. This letter was animated above certain lines and served to review the animation for the students. It also helped to make clear certain intersection principles and other important factors in the problem.

Titling

Titles serve to punctuate the animation, and to

emphasize the parts of the problem which need special explanation. It is imperative that the producer be aware of the major difficulties encountered by students in sheet-metal classes to the end that he may, by means of titles, identify and clarify the important processes presented in the films. This phase of animation is so vital that it may even be necessary to reorganize the titles several times in order for the producer to arrive at a satisfactory punctuation for his animation.

There are certain rules for producing titles, and the producer who wishes to make the best use of this medium of imparting knowledge should keep them in mind at all times. These rules may be stated as follows:

1. Titles must be legible
2. Titles should be well spaced and balanced
3. Size of letters should permit them to be
read without effort
4. Titles should contrast strongly with the
background
5. Titles should have clean-cut, sharp letters
6. Titles should be short and specific
7. Titles should convey a message (2:3)

The above list applies, in general, to the mechanics of making titles for films. Another phase of titling,

which is equally, if not more, important is that of wording. It involves a difficult technique, but in general it may be said that if a title is short, presents significant information not shown in the film, arouses curiosity, stimulates interest in what is to follow, and marks transitions between sequences, it is a good title. There are definite rules, set up through long experience, which should be particularly helpful to the inexperienced animator. These are listed below:

1. Do not use more than twenty to twenty-two words in any title.
2. Do not present more than three ideas in any title.
3. Do not state in a title what is plainly evident in the scenes to follow.
4. Allow one second of reading time per word.
5. Do not splice two titles in succession.
6. Do not break the title sentences into two parts to create "hanging" or suspense titles.
7. Refer always to material that is coming in the film, not to what has passed.
8. Use simple, dignified language to carry your meaning, but do not attract attention to the wording as such.
9. Titles, unless interjections, should be complete sentences containing subject, verb, and object.
10. Title sentences should be completely punctuated, as in any other form of writing. (15:31)

These statements may be used as basic rules for successful title-writing. Moore says in regard to them: "As with all rules, they invite exceptions on occasion, but rightfully so only in the hands of the skilled title writer". (15:32)

There are many styles and types of letters available for use in titling, such as typed titles, printed titles, hand-lettered titles, metal letters, cardboard letters, soup alphabets, wooden letters, paper letters, and clay letters. In this study, clay letters were used for the main titles, and metal letters for all sub-titles throughout the film. Both types of letters are manufactured by commercial companies for specific use in title-making. Both types of letters proved very satisfactory in titling these films. The clay letters are white, and in composition and texture resemble plaster of Paris. The metal letters are a dark, metallic color. Several sizes of letters are available in both types.

The mechanics involved in making titles may be as complex or as simple as the producer desires. In this study, the same method was used for titling as that for the production of the animated pictures. The same animation table, camera, and lights were used.

CHAPTER IV

ANIMATED FILMS IN THE CLASSROOM

The classroom use of animated films will not materially alter the commonly accepted methods of presenting information to students in sheet-metal pattern drafting. Whether the patterns are produced in the drafting room or in the sheet-metal shop, the principles of drafting used to produce them are similar, if not identical. The pupil usually makes his acquaintance with the problem from a drawing, either on a job-sheet or in a text-book. There is also the instructor's demonstration, in which he may draw the pattern on the blackboard or directly on the metal, at the same time explaining the processes involved in its execution.

These animated films were produced for the purpose of supplementing the teacher's demonstration. They may be used in several ways, which are described in the following pages.

A. ANIMATED FILMS AS A PREVIEW

Animated films may be used at the beginning of the semester to orient new students by giving them an overview of the type of work to be covered. This early showing offers an excellent opportunity to impress on pupils

the necessity of following specific procedures in the performance of certain tasks. It is likewise a means of emphasizing the necessity for neatness and accuracy in each step involved in the production of patterns. Furthermore, it is believed that films so used will stimulate interest and promote activity on the part of the pupils.

B. ANIMATED FILMS WITH DEMONSTRATION OF PROJECT

Each new project presented to the class calls for a demonstration of the principles involved in its completion. In making a demonstration, it is essential that the instructor be familiar with the various kinds of visual aids best suited to the type of information he is presenting. The nature of the learning unit naturally determines the type.

The animated films made for this study may be used to good advantage at the beginning of a new learning unit to fortify the teacher's demonstration. The film may be shown immediately before the demonstration, and give the students opportunity to see, in proper sequence, all the processes necessary to draft a pattern correctly. Moreover, this use of animated films helps overcome the difficulty familiar to all teachers of large classes - that of having the demonstration drawing in full view of the entire group. When the animated drawings are projected

on a screen of adequate size, all pupils in the class can see them clearly. Consequently, when the instructor's demonstration follows the showing of the film, the pupils are already on speaking terms with the principles involved, and are better able to grasp the important mechanical processes shown by the teacher. The importance of the above-mentioned projection of a small drawing on a screen sufficiently large to be easily seen by the entire class, and showing each step in motion and in correct order, cannot be too strongly emphasized. "The animated picture can put into motion and into proper interrelationship otherwise invisible processes,"* and thus represents a very important contribution to both teaching and learning.

C. ANIMATED FILMS AS REVIEW

Animated films may well be used to review the processes involved in pattern drafting. Again, it is necessary for the instructor to use the method of presentation that will best serve the purposes of the instruction. It is possible that a showing of the animated film on the specific learning unit or units, together with the instructor's explanation, will serve the needs of the review. In other instances, additional repetition may be advisable.

* Kruse, William F., Manager Films Division, Bell-Howell Company, (In a letter to the writer, May 13, 1940).

Various conditions in each class determine how intensive a review is necessary. If suitable animated films were available for review purposes, and were so used, this important phase of teaching could be cared for effectively and quickly.

D. THE REPEATING FILM

For his knowledge of the equipment necessary to show a repeating film, the writer is indebted to Professors Eby and Welch, experts in the field of visual education at Stockton Junior College and visiting professors in visual education at Oregon State College. These men have developed equipment suitable for the projection of the continuous film, which is described in Fig. 3.

Such equipment is simple and inexpensive, and can easily be constructed in the school shop. It is used with the regular projector and consists of a standard with two parallel rows of pulleys on which the endless film is placed. Instead of using the regular film reels, the film is operated over the parallel rows of pulleys on the standard. (Fig. 3) The standard should be placed on a table either directly in front of or back of the projector. The position of the standard is governed by the design of the projector.

In the projection of film for classroom use, the

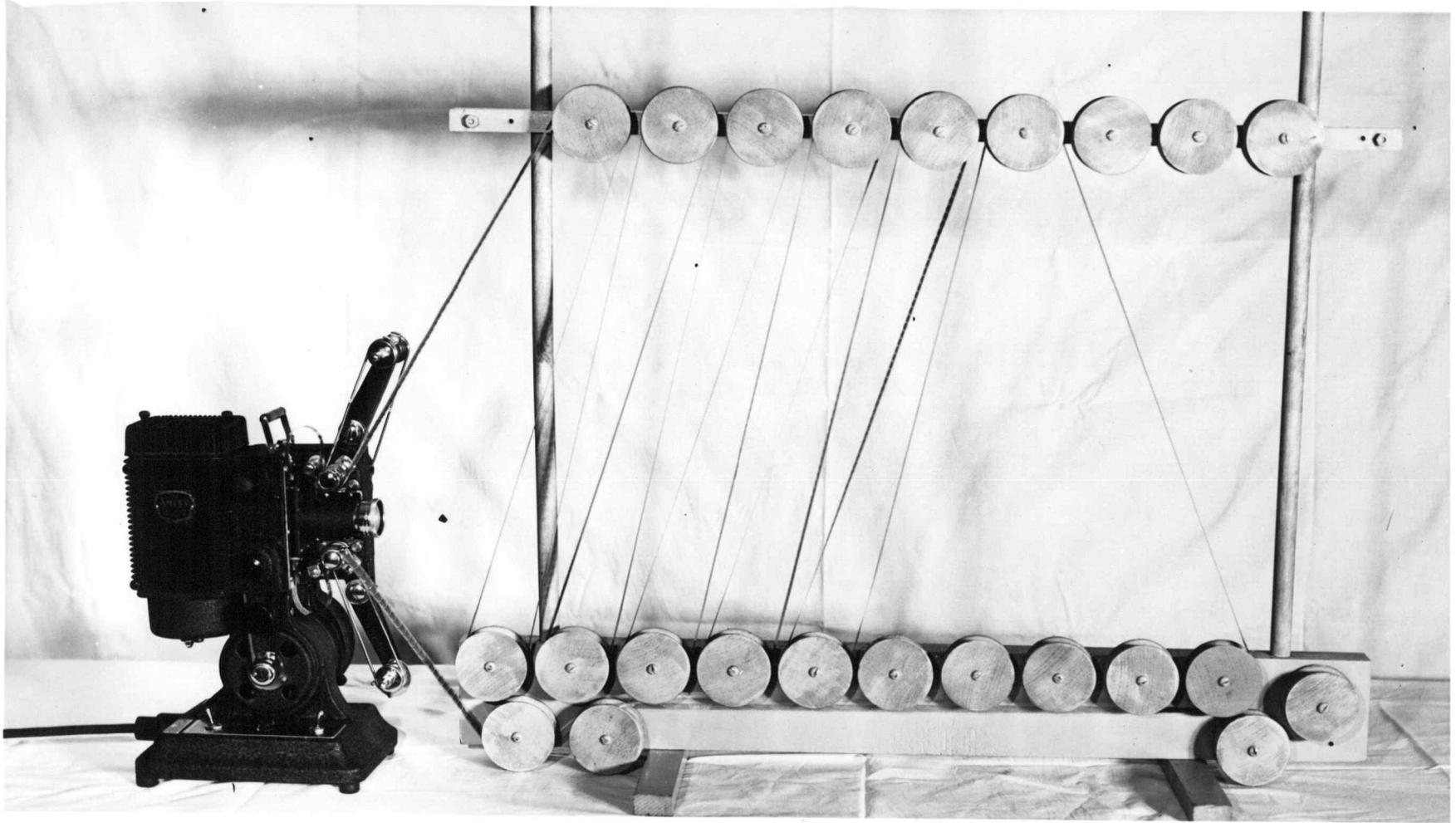


FIGURE 3

REPEATING FILM DEVICE USED WITH A PROJECTOR

repeating device is very important. This is particularly true when it is used in classes involving a wide variation in pupil ability. Most classes include such a variation, and there are always pupils, who, after seeing and hearing the teacher's demonstration, are unable to proceed with their work because they failed to grasp all of the important points. Consequently the teacher must repeat the same subject matter for these pupils, a process which retards the progress of the class as a whole. It is here that the special function of the repeating film is evident. Through the use of the repeating device, the film may be shown continuously, and the pupils may watch the process as many times as are necessary. Those needing it should be encouraged to view the film frequently that they may understand thoroughly the relation of the separate processes to the completed pattern. The equipment may be set up and kept ready for any individual student to operate when he has difficulty in drawing the pattern.

E. OPERATION OF MOTION PICTURE EQUIPMENT

The organization of a motion picture operator's club will add greatly to the effectiveness of setting up and operating the equipment. Clubs of this type have proved very satisfactory in many schools where motion pictures are used frequently. Members of the club not only receive

valuable training and experience in operating motion picture equipment, but they also develop a sense of responsibility in regard to an important school function.

It makes little difference whether the projector is permanently in the room or is kept in a visual equipment room of the school. The writer is a member of the visual education committee in the Grover Cleveland High School in Seattle. There, equipment is kept in a separate room set aside for that purpose. Whenever a teacher needs equipment, he sends a card to the club with information as to time of the showing, name of the film, and equipment required. When the time for the showing arrives, the club has the equipment set up and an operator ready to show the films.

When the repeating film is used, the projector may be left set up in the classroom ready for operation whenever the student desires simply by turning on the switch. It is suggested that in each class a specified student be responsible for operating the repeating film, although this point should be left entirely to the discretion of the instructor.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The writer acknowledges the necessity for controlled tests conducted on films of this type before the educational value of such films can be accurately stated. Such tests were not made in this study because (1) of the great amount of time involved in the construction of the films, (2) of the complications involved in the research, and (3) of the unsatisfactory conditions in which to conduct such tests. Consequently, this important phase of the problem is left for future study.

A. CONCLUSIONS

It is evident to the writer that there is a definite need for further development and research on the problem of the use of animated motion pictures in sheet-metal work. The films produced for this study are only samples of possible animation in sheet-metal pattern drafting, and there are many more units which could be produced in animation for shop use.

Possible uses of animated motion pictures in related fields

It seems possible to the writer that such animation as was developed in this study might well be extended

into fields of work more or less closely related to Industrial Arts. There is no reason why it should not be useful in vocational schools as well as in industrial arts shops. It seems, also, that even certain types of industrial concerns might well utilize such aid in teaching their employees new principles of construction so frequent these days of rapidly changing world conditions. Indeed, it is reasonable to believe, that, whenever an abstract principle is to be taught, the use of animated films might be advantageous to both teacher and learner.

Cost of producing animated films

The production of animated motion pictures is well within the financial scope of the average school teacher. It is not necessary to have expensive and elaborate equipment. Any camera with a single frame attachment should be adequate. Many schools already have excellent motion picture cameras, and if these have attachments for exposing single-frames of film, well and good. If not, the problem is not serious, for it is possible to obtain single-frame attachments for most high-grade cameras. It is possible, although not advisable, to make animation without a single-frame attachment by sharply tapping the exposure button so that it will rebound after one frame has passed the aperture. Far better

results are obtained when the attachment is used, and it is recommended that schools contemplating the purchase of a motion picture camera keep this point in mind.

It is possible to build a reasonably priced and entirely satisfactory animation table in the school shop. (Fig. 4) A drill press can be converted into such a table by fastening the camera onto the standard and using the drill-press table as a rest for the animation board. The animation table used in this work was constructed from a drill press and has proved very satisfactory. Any table with an upright on which the camera can be properly fastened will serve as an animation table.

Floodlights are standard equipment for indoor cinematography and can be obtained at a photograph supply store.

A detailed statement of the expense involved in the production of the animated films for this study is given below. This statement is not intended to imply that all animated motion pictures involve approximately the same costs, for obviously, in other situations, the expense might be entirely different. Fortunately the writer had access to all necessary equipment except flood-lights, drawing materials, and films. Four hundred feet of animated film were produced in this study at a total cost of about fifteen dollars. Of this amount, approxi-



FIGURE 4
THE ANIMATION TABLE

mately six dollars was spent for drawing materials and flood-lights, and about nine dollars for film and film development. It would be safe to say that under present price quotations, materials for animated films such as were made for this study could be produced and developed for somewhat less than four dollars per hundred feet. This cost takes into consideration only the actual materials used in producing the film, namely drawing materials, lights, film, and film development.

A Bell-Howell camera model 70DA with a single-frame attachment, or equal, is recommended for animation work. A camera of this type can be purchased for \$200 and up. The cost of the camera, together with the other equipment, will come within the visual education budget of many schools.

The cost of equipping a laboratory for commercial production of animation would run into several thousand dollars. Cameras for commercial work cost from \$2000 up, and other equipment is correspondingly expensive. The results obtained from the use of school-made animated films in this field may encourage commercial companies to undertake the production of this particular phase of educational films.

Time requirements for production of animated film

This type of film takes far more time to produce than

any other type known to the writer. Considerable time must be spent on the problem before it is ready to be put into animation. The unit must be drawn to the scale which will permit it to be photographed in the field covered by the lens. Then the drawing must be analyzed into proper animation speed. Titles must be organized for certain parts of the process. Finally, when all preliminary work is completed, the problem is ready to be animated.

Each frame of the animated film is a separate photograph. In making it, it is necessary to change the drawing, turn on the flood-lights, manipulate the camera so that one frame of film is exposed, and then turn off the flood-lights. Approximately two hundred hours were spent in the animation of this study, four hundred feet of acceptable animation being produced. There are four thousand frames of sixteen-millimeter film per one hundred feet. A moment's calculation shows, therefore, that the average frame required forty-five seconds for preparing and photographing the drawing. In frames where equipment, as well as the drawing, was animated, more time was needed per frame than for frames where only the drawing was animated. The total number of hours named above included time for changing the film, placing

titles on drawings, replacing the letters in the trays, interruptions, and rest periods for the animator, as well as the actual photography. All these factors are considered in calculating the average time required to make one frame of animation.

B. RECOMMENDATIONS

Suggestions for production of animated motion pictures

Every animated film is a creative job, and no two productions involve identical problems. Successful animation demands most careful thought and planning. However, it is entirely possible for amateurs to obtain satisfactory results in making such films if they are experienced in cinematography and realize the necessity of analyzing the unit or problem to be animated; also, they must be certain that their equipment is adequate and in good working order. Films can be made in schools having such equipment and in which there are staff members sufficiently interested to give time and effort to the undertaking.

Equipment recommended for producing animated films

The equipment listed below is recommended for the production of animated line-drawing films:

1. A high-grade sixteen-millimeter camera with a one-inch lens and a single-frame exposure attachment
2. Unexposed sixteen-millimeter positive film
3. Photo-electric light meter
4. Two photo-flood lamps complete with reflectors, and both controlled with a single switch
5. Complete animation stand with drawing board and upright camera holder
6. Drawing equipment, including India ink, white ink, lettering brushes, speedball pens of various sizes, pencil and ink erasers, set of drawing instruments, T-square, angles, French curves, thumb tacks, scale, scissors, and pencils of various hardnesses
7. A sixteen-millimeter projector for running test film
8. Title letters of various sizes for main and subtitles
9. White drawing paper
10. Sources of technical information regarding the problem

A correction should be made in the design of the camera holder used in this study. The bracket which held the camera was so designed that it was necessary to make all drawings and titles upside down. This was a distinct handicap and added to the time that should have been required to complete the animations. There should be a new fixture to hold the camera in such a

position that the animator can work from the front side of the drawing.

Suggested methods of using animated films

During this research, a question was raised in regard to the methods of using the films. It seemed advisable, therefore, to consult a group of experienced teachers in the field of Industrial Arts. It was reasonable to believe that the opinions of these men would be of value in suggesting methods in which these films could be used to advantage. The opinions were obtained through the use of the other part of the questionnaire described in Chapter I. This, and its analysis are presented in the following pages.

Below are suggestions for possible methods of using animated motion pictures for teaching purposes. Please evaluate them, on the basis of your experience as an Industrial Arts teacher, according to the following scale:

- | | |
|----------------------|--------------------------|
| 1. Of great value | 3. Of questionable value |
| 2. Of moderate value | 4. Of slight value |
| 5. Of no value | |

	1	2	3	4	5
1. Using films only as a preview at the beginning of the semester to give pupils an overview of certain projects or processes					
2. Using films as a preview device, with a follow-up showing of each unit when the class is ready to start a new project or process					
3. Using the films unit-by-unit as the class is ready for them, without previous preview					
4. Using the repeating film in connection with the teacher's demonstration of certain projects or processes. (A repeating film is a film of a single unit with ends spliced together and operated through a projector as many times as is necessary)					
5. Allowing students to run the repeating film as a follow-up of the teacher's demonstration according to their individual needs					
6. Using films as a means of presenting technical information					
7. Using films of this type as a means of creating interest and of increasing activity on the part of the pupils					
8. Using such films as a means of impressing on pupils the necessity of following certain definite procedures					

Please make comments:

(Comments are compiled on page 74.)

TABLE II

COMPILATION OF ANSWERS TO QUESTIONNAIRE ON PAGE 73
IN PERCENTAGES

Question number	Of great value	Of moderate value	Of questionable value	Of slight value	Of no value	Unanswered	Total
1	40	42	12	4	0	2	100
2	85	15	0	0	0	0	100
3	40	48	6	0	0	6	100
4	77	17	4	0	0	2	100
5	62	4	30	2	2	0	100
6	50	42	6	0	2	0	100
7	50	25	19	6	0	0	100
8	72	12	8	6	0	2	100
Total	60	26	10	2	1/2	1 1/2	100

COMMENTS ADDED TO CERTAIN OF THE QUESTIONNAIRES

Question number three: in slow classes, it would be rated #1.

Question number five: it would be difficult in large classes where students are not all working on the same unit.

----- W. Kelly

I believe that the assistance rendered by this method, if any, is not comparable to the effort and time necessary to develop the film. A controlled experiment to determine the value of this method is necessary before considerable effort is expended in the making of them. It is my belief that the opinions I have offered on these pages are not worth much inasmuch as there is no basis for the forming of an opinion on my part.

----- Unsigned

Films may be stopped or re-run, thereby meeting the problem of having a student miss out on a very significant part of the problem.

----- John Mears

I think the spacing of your columns tends to put your answers in 2 and 3 - psychologically. On the second sheet, your questions are designed to build a foundation under your interest - to obtain "yes" answers.

I called Mr. Porter at Garfield, telling him of your work and of the "march" that industrial arts, through you, had obtained over Mathematics. Math. has been taking over our work for years, and slamming it --- or have they? Good work, boy---

----- R.D. Kellogg

It would depend somewhat upon subject matter.

----- Pratt

In addition to animated films, I believe that movies showing correct methods and techniques should be taken and shown in the classroom.

----- J. B. Swanson

The opinions shown on the questionnaire indicate that the great majority of the group favors the use of animated films as a teaching aid. Eighty-six per cent of the answers fall in the columns headed Of great value or Of moderate value. Sixty per cent of the answers rate animated films Of great value for the various questions in the questionnaire. For convenience and brevity of expression, the columns Of great value and Of moderate value will hereafter be designated as columns 1 and 2, respectively.

On further examination, the questionnaire reveals that eighty-two per cent of the answers indicate that the group believes films used at the beginning of the semester to give the pupils an over-view of certain projects or processes should be rated 1 or 2. One hundred per cent give the same rating to the use of the films as a preview device with a follow-up of each unit when the class is ready to start new work. Eighty-eight per cent have rated the use of the films unit-by-unit without previous preview in columns 1 and 2. In regard to the use of the repeating film in connection with the teacher's demonstration of certain projects or processes, 94 per cent have checked either column 1 or column 2. Only 66 per cent checked either of the first two columns

when the repeating film was to be used by pupils according to their individual needs.

The last three items in the questionnaire are concerned with specific purposes the films might serve rather than with methods of using them. In analyzing the answers to these, it is found that 92 per cent have checked one of the first two columns for the use of the films as a means of presenting technical information. Seventy-five per cent have rated in the same columns the use of films as a means of creating interest and increased activity on the part of the pupils. Eighty-four per cent have given the same rating to the use of films as a means of impressing on pupils the necessity of following certain definite procedures.

It is interesting to note the topics of the questionnaire that received the high ratings. Of the five topics dealing with method, the highest rating goes to topic 4 - "Using the repeating film in connection with the teacher's demonstration of certain projects or processes". In the topics dealing with purpose, number 7 - "Using films of this type as a means of creating interest and of increasing activity on the part of the pupils" ranked first.

It should be emphasized that the rating of the various topics on the questionnaire represents opinions

only, and that no final conclusions can be drawn from them. However, since they are opinions expressed by men experienced in various phases of industrial arts teaching, it is reasonable to believe that they should be given serious consideration in the selection of methods for using these animated films.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Amateur Cinema League, Inc. The ACL Movie Book. New York Amateur Cinema League, Inc., 1940.
2. Beach, Fredrick G. Titling technique. New York, Amateur Cinema League, Inc., 1938.
3. Clarke, Carl D. The fundamentals of animated scientific drawing and cinematography. The Journal of Biological Photographic Association, 6:1-25, September, 1937. Baltimore, The Williams and Wilkins Company, 1937.
4. Cox, George B. Things to come in education. Industrial Arts and Vocational Education, 29:41-44, February, 1940.
5. Dale, Edgar, Dunn, Fannie Wyche, Hoban, Jr., Charles, Schneider, Etta. A summary of literature. Motion Pictures in Education. New York, The H. W. Wilson Company, 1937.
6. Doane, Donald C. What makes a good educational film? Educational Screen, 15:203-06, September, 1936.
7. Doane, Donald C. What makes a good educational film? Educational Screen, 15:305-07, December, 1936.
8. Ellis, Don Carlos and Thornborough, Laura. Motion pictures in education. New York, Crowell Company, 1923.
9. Gramet, Charles A. Making an educational movie. Educational Screen, 13:5-7, January, 1934.
10. Gregory, W. M. Standards in geographical film for instruction. Educational Screen, 19:95-96, 120-123, March, 1940.
11. Hoban, C. F., Hoban, Jr., C. F., and Zisman, S. B. Visualizing the curriculum. New York, The Gordon Company, 1937.
12. Lake, Charles H. Adapting visual materials to instruction. Educational Screen, 18:113-14, April, 1939.

13. Longfield, Ellsworth M. Sheet metal drafting. New York, McGraw-Hill Book Company, Inc., 1921.
14. Maddock, W. H. Problems in the production of educational motion pictures. Educational Screen, 19:107-10, March, 1940.
15. Moore, James W. Wording titles with Beach titling technique. New York, Amateur Cinema League, Inc., 1938.
16. Ramsaye, Terry. A million and one nights. New York, Simon and Schuster, Inc., 1926.
17. Selvidge, R. W. and Christy, Elmer W. Instruction manual for sheet metal workers. Peoria, Illinois. The Manual Arts Press, 1925.
18. Standards of attainments in industrial-arts teaching. A report from a committee of the Industrial-Arts Section of the American Vocational Association, December 7, 1934. Bloomington, Illinois, Pantagraph Printing and Stationery Company, 1934-35-37.
19. Talbot, Fredrick A. Moving pictures, how they are made and worked. Philadelphia, J. B. Lippincott Company, 1923.
20. Welch, R. L. Elements of sheet metal work. Milwaukee, Wisconsin, The Bruce Publishing Company, 1923-1926.

APPENDIX

ADDITIONAL SOURCES OF INFORMATION

Copy of letter-form sent to thirty-four manufacturers of cinematography equipment, or producers or distributors of educational films:

Dear Sirs:

I am writing you to inquire whether or not you have any information on educational animated motion pictures that you would be willing to send me. I have been doing graduate research work in visual education at Oregon State College, Corvallis, Oregon, for the past four summers, and expect to complete the study this summer. My position is instructor of industrial arts, Cleveland High School, Seattle, Washington.

My problem is to construct animated motion pictures of selected teaching units in the field of industrial arts. The experimental films I have already made are line drawings, showing the correct procedure to be followed by students in drawing patterns for sheet-metal projects. I have made, also, some units in geometry, showing methods of constructing octagons, hexagons, and pentagons.

In this study, I am attempting to show the possibilities of using animated films to help the teacher to be more efficient in teaching specific units in the curriculum. There are many units in industrial arts, science, and mathematics which involve action and motion. To me, it seems that there are great possibilities of improving teaching techniques by using properly constructed animated films in such units of work.

In order to enrich this study, I am particularly anxious to obtain more information on the following topics:

1. Short descriptions of available educational animated motion pictures
2. Suggestions for constructing such films
3. Any history you have on this type of film
4. Advantages and disadvantages of producing and using this type of film

I will greatly appreciate your sending me material on any of the above items or on any related topics that you think might be useful in working out this study.

Thanking you, I am

Yours very truly,

John M. Speer

To the 27 companies which replied to the letter on the preceding page, the writer is greatly indebted for their generous cooperation and encouragement, and he wishes to thank, especially, the following for their assistance:

Amateur Cinema League, Incorporated
420 Lexington Avenue, New York City

Charles J. Hoban, Jr.
American Council on Education
744 Jackson Place
Washington, D. C.

Bailey Film Service
328 Markham Building
Hollywood, California

William F. Kruse, Manager Films Division
Bell-Howell Company
1801-1815 Larchmont Avenue
Chicago, Illinois

H. F. Driscoll, Educational and Vocational Division
Bell and Howell Company
1801-1815 Larchmont Avenue
Chicago, Illinois

College Film Center
59 East Van Buren Street
Chicago, Illinois

William H. Dudley Visual Education Service
736 South Wabash Avenue
Chicago, Illinois

James A. Brill, Director of Production
Erpi Classroom Films, Incorporated
35-11 Thirty-fifth Avenue
Long Island, New York

James R. Brewster, Director
Harvard Film Service
Biological Laboratories, Harvard University
Cambridge, Massachusetts

H. L. Kooser, Director
Visual Instruction Service
Iowa State College
Ames, Iowa

Ellsworth O. Dent, Director Educational Department
RCA Manufacturing Company, Incorporated
Camden, New Jersey

SELECTED LIST OF AVAILABLE EDUCATIONAL
ANIMATED FILMS (16 MM)

<u>TITLE</u>	<u>DISTRIBUTOR</u>	<u>KIND</u>
<u>BIOLOGY</u>		
Plant Growth.....	Bell-Howell.....	Sound
Plant Life.....	Films, Inc.....	Sound
Romance of Life.....	Films, Inc.....	Silent
From Flower to Fruit.....	Dudley Vis. Ed. Serv	Silent
Heredity.....	Erpi Class. Films....	Sound
Plant Growth.....	" " "	"
Roots of Plants.....	" " "	"
Leaves.....	" " "	"
Flowers at Work.....	" " "	"
Fungous Plants.....	" " "	"
The Dodder.....	" " "	"
Butterflies.....	" " "	"
<u>CHEMISTRY</u>		
Oxidation and Reduction.....	" " "	"
Molecular Theory of Matter..	" " "	"
Electrochemistry.....	" " "	"
Colloids.....	" " "	"
Velocity of Chemical Reactions.....	" " "	"
Catalysis.....	" " "	"

<u>TITLE</u>	<u>DISTRIBUTOR</u>	<u>KIND</u>
<u>ASTRONOMY</u>		
Tidal Theory of the Earth's and the Moon's Creation	W. O. Gutlohn.....	Sound
Comets.....	Films, Inc.....	Silent
Eclipse of the Sun.....	" "	"
If We Lived on the Moon....	" "	"
Birth of Our Earth.....	Akin and Bagshaw.....	"
The Earth in Motion.....	Erpi Class. Films....	Sound
The Solar Family.....	" " "	"
The Moon.....	" " "	"
Exploring the Universe.....	" " "	"

PHYSICAL GEOGRAPHY AND GEOLOGY

The Earth and Its Seasons..	Films, Inc.....	Sound
The Earth's Rocky Crust....	" "	"
Erosion by Wind and Water..	" "	"
The Mysteries of Water.....	" "	"
Earth, Latitude, and Longitude.....	" "	"
Tides and the Moon.....	" "	Silent
The Water Cycle.....	Akin and Bagshaw.....	"
Ground Water.....	Erpi Class. Films....	Sound
Mountain Building.....	" " "	"
Volcanoes in Action.....	" " "	"

<u>TITLE</u>	<u>DISTRIBUTOR</u>	<u>KIND</u>
<u>PHYSICS</u>		
The Electric Bell.....	Films, Inc.....	Silent
How the Telephone Talks.....	" "	"
The Einstein Theory.....	Dudley, Vis. Ed Serv	"
Chemical Effects of Electricity.....	" " " " "	"
Lenses.....	" " " " "	"
Structure of the Molecule....	" " " " "	"
Four-Cycle Gas Engine.....	" " " " "	"
Heating Hot Air.....	" " " " "	"
Refrigeration.....	" " " " "	"
Sound Waves.....	Bell-Howell.....	"
Electrostatics.....	Erpi Class Films...	Sound
Electrodynamics.....	" " " ...	"
Electrons.....	" " " ...	"
Sound Waves and Their Sources	" " " ...	"
Fundamentals of Acoustics....	" " " ...	"
Light Waves and Their Uses...	" " " ...	"
Thermodynamics.....	" " " ...	"
Fuels and Heat.....	" " " ...	"
Distributing Heat Energy.....	" " " ...	"
Magnetic Effects of Elec- tricity.....	Akin and Bagshaw...	Silent
Induced Currents.....	" " " ...	"
Electrostatics.....	" " " ...	"

<u>TITLE</u>	<u>DISTRIBUTOR</u>	<u>KIND</u>
Wizardry of Wireless.....	Akin and Bagshaw....	Silent
The Power Within.....	" " "	"
Water Power.....	" " "	"

PHYSIOLOGY

The Circulatory System.....	Films, Inc.....	Silent
Human Development.....	" "	"
Action of the Human Heart...	" "	"
How We Breathe.....	" "	"
How We Hear.....	" "	"
How You See.....	" "	"
The Skin.....	Dudley Vis Ed Serv..	"
The Heart and How it Works..	Bell-Howell.....	"
Human Development.....	"	"
The Blood Vessels.....	"	"
Mechanisms of Breathing.....	Erpi	Sound
The Heart and Circulation...	"	"
Body Defenses Against Disease.....	"	"
The Nervous System.....	"	"
Digestion of Foods.....	"	"
The Alimentary Tract.....	"	"
Endocrine Glands.....	"	"
Reproduction Among Mammals..	"	"
Breathing.....	Akin and Bagshaw....	Silent

<u>TITLE</u>	<u>DISTRIBUTOR</u>	<u>KIND</u>
Circulation.....	Akin and Bagshaw....	Silent
Muscles.....	" " "	"
The Human Voice.....	" " "	"
The Eyes.....	" " "	"
Care of the Teeth.....	" " "	"

HEALTH AND SAFETY

Breath and Heart Beat.....	Bell-Howell.....	Silent
Voice and Hearing.....	"	"
Fly as a Disease Carrier...	"	"
How the Mosquito Spreads Disease.....	"	"
Confessions of a Cold.....	Akin and Bagshaw....	"
Tuberculosis.....	" " "	"
Foods and Nutrition.....	Erpi	Sound

MATHEMATICS

Rectilinear Coordinates....	Bell-Howell.....	"
The Play of the Imagination in Geometry.....	Erpi	"