The teaching of plastics assembly utilizing an experimental sound or silent film combined with programmed instruction

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Eugene Wayne Balzer

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INTRODUCTION

This is an era of rapid and at times radical change. The changes affect more than social and moral fibers of society, they touch on educational and technical aspects as well. Industrial education teachers are faced with the task of keeping students abreast of the changes in their world. For industrial education this includes knowledge of the plastics industry.

The plastics industry has grown in the last two decades. The growth has averaged 15% per year. This is four times the rate of growth of the Gross National Product. The volume of plastics used by 1983 is estimated to exceed the volume of metals (25).

Leaders in the plastics industry want specialized and broad programs of plastics taught at junior high, high schools, and college levels (28). This is in keeping with one of the goals of industrial education mainly to develop an understanding of industrial processes and their applications. Schools cannot ignore knowledge of an industry as large as plastics and appear relevant to the students. Neither can they limit industrial plastics education to fiberglass trays and craft items such as key chain trinkets. The author estimates there are at least 40 different kinds of plastics and at least 15 important processes involved in the industry.

Teachers of industrial plastics are faced with the task of
teaching concepts of the plastics industry. The curriculum for industrial education must be designed to challenge the superior student, provide constructive experiences for the average student, and encourage the slower and reluctant student. The learning must be based on the study and application of knowledge related to concepts. Generally for industrial education this means laboratory equipment and laboratory experiences. This works well if the schools have money to buy equipment, and the teachers are prepared to organize instructional materials. However, if schools can't afford expensive equipment and a relatively new area like plastics is introduced, teachers are faced with developing new effective methods of instruction.

The industrial education teacher who has the problem of lack of equipment either ignores the concept centered around the equipment, or he attempts to teach as best he can with the instructional materials he can develop.

The author is aware of the scope of the plastics industry. The author has also had experience teaching high school industrial arts, has faced the problem of lack of equipment and is aware of financial problems. This study was undertaken to develop an effective method for teaching concepts of plastics without having equipment available to the students.

If industrial education is to remain credible to its students it must find ways to synthesize industrial concepts with instructional methods. There exists a need to investigate instructional methods to determine those most effective in
Purpose

The purpose of this study was to identify an instructional method that was effective when teaching an industrial machine oriented concept without having equipment available to the students.

The study investigated the effectiveness of four instructional methods. The design and development of materials for the four methods was necessary to conduct the investigation. The instructional methods were: programmed instruction, programmed instruction plus silent film, programmed instruction plus sound film, and the transparency lecture method. Throughout the remainder of this study the four instructional methods are identified as T I, T II, T III, and T IV, respectively.

The concept involved was the assembly of prefabricated parts. Specifically the study concerned itself with metal to plastics assembly.

Two problems of special interest to the author were investigating the differences in achievement when comparing silent film to sound film utilizing programmed instruction to provide background information, and investigating the differences in achievement when comparing packaged media materials to teacher presented transparency lecture method of instruction. There were financial and technical reasons for these investigations. Programmed instruction books are relatively inexpen-
sive to produce when compared to 16mm silent or sound films. The author investigated these areas to identify his most effective least expensive instructional method of teaching a machine oriented concept.

Scope

The assembly of prefabricated materials is a broad industrial concept. This study was limited to the concept of metal to plastics assembly. It involved two operations; inserting and staking.

Instructional materials were developed to teach the assembly concept by four different methods.

The four instructional methods on the assembly concept were presented to eight industrial arts classes. Four classes at Park Center Senior High School and four at Osseo Senior High School. Both schools are in the Osseo Public School System, Osseo, Minnesota.

The instructional methods were randomly assigned to the classes. The total number of students in all eight classes was 119. Complete data were not available on some students and they were dropped from the analysis. The final analysis involved 99 students.

Objectives

The objectives of the study were:

1. To identify an instructional method that was effective
when teaching an industrial machine oriented concept without having equipment available to the students.

2. To investigate which of the four instructional methods when comparing programmed instruction method, programmed instruction plus silent film method, programmed instruction plus sound film method, and transparency lecture method of instruction was the most effective in terms of average class achievement in the subject of metal to plastics assembly by the ultrasonic method.

3. To investigate the instructional method which was most effective when comparing programmed instruction method, transparency lecture method, to programmed instruction plus silent film method, and programmed instruction plus sound film method in terms of average class achievement in the subject of metal to plastics assembly by the ultrasonic method.

4. To investigate the instructional method which was most effective when comparing programmed instruction plus silent film method to programmed instruction plus sound film method in terms of average class achievement in the subject of metal to plastics assembly by the ultrasonic method.

5. To investigate the instructional method which was most effective when comparing programmed instruction method to transparency lecture method in terms of average class
achievement in the subject of metal to plastics assembly by the ultrasonic method.

6. To investigate the attitudes of students receiving the various instructional methods.

Teaching Design

Eight senior high school industrial plastic classes were used in this study. The four instructional methods of teaching the unit of metal to plastics assembly were randomly assigned to the classes. Each method was taught to two classes.

All of the classes were given a mechanical reasoning test and a plastics assembly pretest. Each test was given during a separate class period.

One school week later the four randomly assigned methods were presented. The programmed instruction book was treatment I (T I). The students worked individually on the instruction books for a total of five class periods. One class period equals 50 minutes. In treatment II (T II) classes, the students worked on the programmed instruction books for five class periods and viewed the silent film twice. The classes assigned treatment III (T III) worked on the programmed book for five class periods and viewed the sound film twice. The classes assigned treatment IV (T IV) received a transparency lecture method of instruction on metal to plastics assembly. This method also involved five class periods. All of the treatments were presented during the same week.
Analysis of covariance was used to analyze the data collected from 99 students in the eight industrial plastics classes. The criterion was metal to plastics assembly achievement. The independent groups were: (T I) programmed instruction on metal to plastics assembly, (T II) programmed instruction plus silent film on metal to plastics assembly, (T III) programmed instruction plus sound film on metal to plastics assembly, and (T IV) a transparency lecture method of instruction on metal to plastics assembly.

Student differences were controlled by grade level, mechanical reasoning test scores, verbal IQ scores, nonverbal IQ scores and metal to plastics pretest scores.

Null Hypotheses

The following null hypotheses were tested:

1. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between T I programmed instruction on metal to plastics assembly, T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, and T IV a transparency lecture method on metal to plastics assembly, when the differences between groups are statistically adjusted for grade
level, mechanical reasoning, verbal IQ, nonverbal IQ and metal to plastics pretest scores.

2. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T I programmed instruction on metal to plastics assembly, T IV transparency lecture on metal to plastics assembly and the average score from T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

3. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T II programmed instruction plus silent film on metal to plastics assembly, and the average score from T III programmed instruction plus sound film on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.
5. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T I programmed instruction on metal to plastics assembly, T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, and the average score from T IV a transparency lecture method on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

Definitions

For the purpose of this study these definitions were used:

1. **Concept** - a fundamental principle and idea common to and drawn from all disciplines or areas of knowledge related to the total structure of industry and providing a method for the transfer of knowledge not limited by boundaries of specific materials.

2. **Inserting** - encapsulating metal in thermoplastic.

3. **Metal to plastics assembly** - a process of assembling prefabricated parts by the operations of inserting and staking.
4. **Programmed instruction** - sequenced information divided into short sentences, paragraphs or concepts called frames, these frames organized into a book required the learner to read and then write short responses.

5. **Silent film** - a 16mm movie film with superimposed informative words and no audio track.

6. **Sound film** - a 16mm movie film with audio track and no superimposed informative words.

7. **Staking** - reforming a thermoplastic stud over metal to create a locking head.

REVIEW OF LITERATURE

This study investigated the effectiveness of four methods of instruction. The teaching of the instructional materials, and the evaluation of their effectiveness depends on communication. The sequence of communication events as given by Kemp (15) are as follows: source of message, message encoded, transmission channels, message received and decoded, and destination of message. (See Table 1)

Table 1. Communication model

<table>
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<tr>
<th>Source of message</th>
<th>Message encoded</th>
<th>Transmission channels</th>
<th>Message received and decoded</th>
<th>Destination of message</th>
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<td>Noise</td>
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<td>Feedback</td>
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A classroom situation will further explain the communication model. A teacher (source of message) has knowledge about a specific concept. This knowledge is then organized (message encoded) into words. These words are printed on paper (transmission channel). The words printed on paper are read by students (message received). The student through his nervous system absorbs and decodes the message.

If the teacher is to evaluate the effectiveness of the communication, feedback is required. This feedback from students to teachers can be accomplished in many different ways.
Testing is one of the most common methods used in education. In the author's study two methods of feedback were provided. One was to measure the effectiveness of the instructional methods. The other in the form of an attitude scale indicated student feelings on the instructional methods.

Film Research

An interest in film making motivated the author to review studies dealing with communication channels. Travers (27) in his book has a section dealing with relative efficiency of auditory and visual channels. He states:

"One cannot reasonably ask the general question whether the eye or the ear is more efficient for the transmission of information, for clearly some information is more efficiently transmitted by one sensory channel than by another." (27, p.88)

This statement has a direct relationship to the author's study. Some methods of transmission should work better than others for given subject matter. For instance an industrial machine operation could better be taught visually than by lecture methods.

Additional studies on the transmission of information by eye and ear were funded by Eastman Kodak Company. To summarize the funded projects by Eastman Kodak Company, Hoban and Van Ormer (12) state:

"Learning is especially aided when the film is designed to convey the material clearly through the picture, or visual medium, and not overload the verbal medium (the titles in silent films or the commentary in sound films)." (12, p.2-3)
May and Lumsdaine (18) and Jaspen (13) agree with the above statements on overloading the verbal medium. These statements about the transmission channels influenced the author in his film making. In both the sound and silent versions the emphasis was placed on the visual with narration and overlays used sparingly to support the visual.

Visual information is less ambiguous than auditory information, but visual information does have one large negative point associated with transmission of information. The point is that the receiver must be physically and mentally prepared to receive the visual information. Whereas auditory information is received regardless of preparation.

A large amount of information has been written concerning repetition in the transmission of information. Hoban and Van Ormer (12) indicates the general feeling about repetition when they state:

"Although repetition may be distasteful to instructional film producers from an aesthetic, artistic or filmic point of view, and may be contrary to the prevailing practice of producing films to amuse an audience, the experimental fact seems to be that repetition, in a film or of a film is a major factor of instructional effectiveness." (12, p.8-30)

A critical factor with repetition is that a film may become monotonous. The rate of development or pacing must move slow enough to allow students to absorb the information, but fast enough to avoid boredom.

Jaspen, (14) in a study on pacing indicates that a slow rate of development is more desirable than a rapid rate of
development. The idea of slow pacing was given a different point of view in a study by W. S. Vincent, P. Ash, and L. P. Greenhill (1949). This study was reviewed by Hoban and Van Ormer (12) and it was found that within certain limits the more information included in a film the greater amount was learned.

A generalization of these studies is that the rate of presentation depends on the complexity of the subject matter and character of the audience.

The transmission of information in films can be summarized with the following:

1. Films should carry most of the information in visuals and a small amount of information in titles or narration.

2. Repetition of small parts of the film is desirable.

3. The pace of the film should be fast enough to avoid monotony, but slow enough to allow the information to be absorbed.

There has been a great deal of research conducted on instructional films. Much of the early research was done under poor experimental conditions, but it has improved in recent years. The author in this chapter has limited the review of studies only to those appropriate to his investigation.

Before the introduction of sound films, research conducted indicated silent films were superior to other methods of instruction. Many of the studies were unpublished masters reports reviewed by Hoban and Van Ormer (12). In reviewing the
literature on silent films one must keep in mind this research was done prior to 1941 and was subject to poor evaluation methods. Many of these studies used small numbers of students with simple experimental designs.

Educators, when introduced to sound films, had mixed reactions. Saettler (23) writing about the history of instructional films of the late Twenties states:

"Some educators repudiated the old silent films; others rejected the new sound films; still others refrained from either open approval or disapproval until they became convinced that the addition of sound was not just another technical novelty." (23, p.110)

This skepticism about sound films compared to silent films remained for many years. There also was a skepticism about the worth of films in education. Not until the Army and Navy jointly sponsored the Instructional Film Research Program, were films critically tested for their effectiveness in learning (23).

A very appropriate study by VanderMeer (29) dealt with the effectiveness of films exclusively, films plus study guide, and standard lecture methods. The results from this study indicated that the films were better than standard lecture, but the difference was not significant. The conclusions of this study were:

"The overall results of this study suggest that a body of factual information such as high school general science, may be taught by films alone, almost as effectively as by a teacher using conventional classroom methods (except films), and by films introduced and supplemented by brief study guides perhaps a little more effectively than by conventional non-film teaching method." (29, p.2)
The use of a study guide is almost always standard procedure with silent films, but not with sound films. This prompted the author to use a programmed instruction book with his study in place of a study guide.

Several studies investigated whether films alone can teach factual information. Harby (10) in teaching an athletic skill found that films proved as effective as actual demonstrations by an instructor.

In summarizing the literature on films the research indicates that films are as effective as other methods of instruction. Several conclusions can be drawn. The author finds some merit in the statement made by McCoy (19) when he writes:

"While film research results provide valuable general guidance it was found in practice that most of the decisions that have to be made in film making must still be made for each specific film production." (19, p. 24)

Later in his conclusions McCoy (19) feels that instructional films must take a learner oriented approach. The author agrees completely and it was found that one way to insure a learner oriented approach was through behavioral objectives. As stated previously the production of all materials in the author's study used the learner approach with behavioral objectives to indicate the desired outcome.
Programmed Instruction

Programmed instruction as Saettler (23) writes had its early beginning with Maria Montessori, Sidney J. Pressey, and E. F. Skinner. Programmed instruction whether centered around machines or books claims to have some advantages over other methods of instruction. One of the more commonly given advantages of programmed instruction is that the student is independent from the teacher. Individual students can work at their own pace. This allows the student to adjust for his individual differences, thus reducing failure among students.

The research conducted on programmed learning was usually done by comparing one teaching method to programmed instruction. Examples are: traditional lectures to programmed instruction, demonstrations to programmed instruction, and other similar comparisons. Even though the comparative studies were done using controlled experimental designs the majority indicated no significant differences in the methods of instruction.

Although the research showed no significant differences the researchers concluded that students learn from programmed instruction as well as through other methods of instruction. Brown, Lewis and Harcleroad (4) summarize the research of programmed instruction with the following statements:

"A student learns when carefully prepared programmed materials are presented by a book or machine. Programmed instruction is effective both with a variety of learners (children and adults; college students and military trainees; mentally retarded, gifted, normal, and deaf persons) and in a variety
of subjects (chemistry, electronics, psychology, spelling, and others)." (4, p.125)

It was from these statements that the author considered programmed instruction to be one method of presenting information about industrial concepts. Even though there are some negative aspects to programmed instruction.

Not all literature on programmed instruction points out its positive aspects. There is literature which stresses the order of presenting information and not on the worth of programmed instruction.

Thelen (26) in questioning programmed instruction makes this statement:

"... while the art of programming is very much concerned with developing an effective sequence of items, two experiments have already revealed that the students learn just as much when the items were presented in random order as when they were presented in the sequence designed by the programmers." (26, p.191)

This statement questioning linearity in programmed instruction is meaningful to industrial concepts utilizing programmed instruction. Industrial concepts like the one dealt with in the above study are complex in nature and not easily structured into a linear form of programmed instruction. If linearity has nothing to do with learning this allows the programmer to concentrate on writing quality items rather than on sequencing the items.

Other literature on programmed instruction is centered around the learner. Leedham (16) states the following:
"Without adequate measurement techniques these are merely observations, but it does appear that this type of learning can be very effective but tiring. After only twenty minutes a pattern of group success or failure is apparent and fatigue appears to be associated with this to some degree." (16, p.40)

Few of the studies indicated that students become tired of using programmed instruction. It seems that researchers generally avoid writing about this negative aspect. Because students tire when using programmed instruction the author when designing his book organized the information into short linear units hoping to break up the monotony.

There is also an indication that students become bored when using programmed instruction. Austin (1) indicates that when students become bored with programmed instruction they skip parts of programmed instruction materials, thus defeating the objective of programmed instruction.

Planning Instructional Materials

Brown, Lewis and Harcleroad (4) Kemp (15) and Mager (17) agree that once the student has been identified the final outcome of student learning must be identified in behavioral objectives. Kemp (15) in writing on planning of instructional materials states:

"Today much attention is given to the literature to the topic of Behavioral Objectives; these have a key role in instructional design as well as in separate learning activities. (15, p.23)

Behavioral objectives influenced the development of the instructional materials in this study. Mager (17) and Popham
and Baker (22) in their books on instruction provided the information to write correct behavioral objectives.

Mager (17) summarized that behavioral objectives should include the following:

"A statement of instructional objectives is a collection of words or symbols describing one of your educational intents. An objective will communicate your intent to the degree you have described what the learner will be doing when demonstrating his achievement and how you will know when he is doing it. To describe terminal behavior (what the learner will be doing): a. Identify and name the over-all behavior act, b. Define the important conditions under which the behavior is to occur (given or restrictions, or both), c. Define the criterion of acceptable performance." (17, p.53)

Summary

Quality communication with provision for feedback is essential for effective research investigations. Feedback allows measuring the effectiveness of compared instructional methods.

Research indicates information transmitted over the correct channel will benefit learning. Some information is better adapted to a visual medium. For effective learning, research also demonstrated visual presentations should not be overloaded with verbal messages. Learning can also be affected by pacing. The medium must move at a proper rate without being too slow or too fast.

Instructional films have been the subject of a great deal of research. The studies indicated films were as effective as
other methods of instruction and in some cases more effective. Films which are supported by a study guide were more effective than those without study guides.

Programmed instruction can be utilized by a variety of subjects. There are many advantages to programmed instruction, but there are also some disadvantages. The advantages are concerned with student independence from the teacher. This individualized instruction allows the student to learn at his own pace. The disadvantage is that students become tired and bored with programmed instruction and thus do not progress at a desirable pace.
DEVELOPMENT OF INSTRUCTIONAL MATERIALS

After the design of the study the process of developing the instructional materials was undertaken by first writing behavioral objectives and then producing the materials. In this chapter the instructional materials will be explained in the order that they were developed. No matter what instructional method was used, the materials followed the objectives.

Behavioral Objectives

After receiving one of the methods of instruction the student, given a 41 item multiple choice test will be able to select the correct answer to the best of his ability on:

a. The definition of ultrasonic vibrations.
b. The principle upon which ultrasonic assembly is based.
c. The two methods of metal to plastics assembly.
d. The components in the electrical and mechanical system in order of energy flow.
e. The purpose of the electrical and mechanical components.
f. The sequence of energy flow in the electrical and mechanical components.
g. The functions of the power supply, converter, and horn.
h. The normal line voltage outlet, power supply, converter, and horn.
i. The definition of inserting.
j. Why metal inserts are knurled.
k. Why the premolded or drilled hole is slightly smaller than the insert.
l. Where localized heat is generated with the operation of inserting.
m. Where the vibrations travel with the operation of inserting.
n. The names of parts in the operation of inserting.
o. The vibration phase in the operation of inserting.
p. The definition of staking.
q. The names of parts in the operation of staking.
r. The difference between high and low profile.
s. The vibration phase in the operation of staking.
t. The total length of the time needed to assemble metal to plastics parts.

For purposes of this study the author developed a 43 page programmed instruction book, wrote, directed, and edited a 10 minute 16mm film in two versions (one sound and one silent) and designed five transparencies with lesson plans.

The ultrasonic assembly equipment used in this study was provided by Branson Instruments. They had also experimented with programmed instruction as a sales promotion technique. Their programmed instruction book however was not adaptable to classroom use, though the content of both books covered the subject of ultrasonic assembly.
Programmed instruction books contain information broken down into short sentences or paragraphs called frames. The frames of information require the learner to read and then write short responses. The repetition of reading and writing small parts of information should produce measurable learning.

In writing the programmed instruction book the author had available to him a programmed instruction book from Branson Instruments. Their programmed instruction book was not adaptable to classroom use, but it did provide some direct information for the author's book.

The steps taken to write the programmed instruction book were: working with the assembly equipment, writing the behavioral objectives, writing the program, rewriting to improve the program. Setting up the ultrasonic equipment required several days. Experimentation with the equipment to achieve proper operation required several additional days.

The author, after reading the Branson programmed instruction book (3) along with their advertising brochures, began writing the behavioral objectives. The behavioral objectives were developed following the suggestions of Mager (17) and Popham and Baker (22).

The linear single response program pattern was selected for the author's programmed instruction book. This program was selected because it had a sound historical background and was
easily adaptable to book form. The linear program required all students to complete the same items in the same sequence. The program book was designed to be completely self-contained. This allowed students to work at their own pace without the aid of a teacher.

The first writing of the programmed instruction book required approximately 40 hours. Much of the information was written in a random order rather than a logical sequence. Rewriting and reorganization of the items provided a logical sequential programmed instruction book. This book was proof read and later administered to industrial education college students. No complications were noted, so the book was considered usable for the study.

In the programmed book Introduction, Part I, the frames of information gave an overall view of the concept of metal to plastics assembly by the ultrasonic method. Specifically the information covered was:

a. The definition of ultrasonic vibrations.

b. The principle upon which ultrasonic assembly is based.

Minor information in Part I, covered the following:

c. The components in the electrical and mechanical system in order of energy flow.

d. The purpose of the electrical and mechanical components.

e. The sequence of energy flow in the electrical and mechanical components.
g. The functions of the power supply, converter, and horn.

Inserting and Staking, Part II, gave in-depth information on the operations of inserting and staking. The information covered was:

i. The definition of inserting.

j. Why metal inserts are knurled.

k. Why the premolded or drilled hole is slightly smaller than the insert.

l. Where localized heat is generated.

m. Where the vibrations travel with the operation of inserting.

n. The names of parts in the operation of inserting.

o. The vibration phase in the operation of inserting.

p. The definition of staking.

q. The names of parts in the operation of staking.

r. The difference between high and low profile in the operation of staking.

s. The vibration phase in the operation of staking.

Ultrasonic Assembly Equipment, Part III, gave specific information on the following:

d. The components in the electrical and mechanical system in order of energy flow.

e. The purpose of the electrical and mechanical components.

f. The sequence of energy flow in the electrical and mechanical components.

g. The functions of the power supply, converter, and horn.
h. The normal line voltage outlet, power supply, converter, and horn.

Film Sound and Silent

For the development of the sound and silent 16mm, 10 minute film titled *Metal to Plastics Assembly*, the author acted as writer, director, and editor. Since the author had no previous motion picture photography background, approximately 90 hours were spent observing and helping film makers at Iowa State University's Film Production Unit. The hours of observations and work involved all phases of film production from scripting to the final screening of the answer print.

Setting up the ultrasonic assembly equipment required several days. Experimentation with the equipment to achieve proper operation required several additional days.

The storyboard script format was used for the shooting script. Camera shots were mentally visualized, then sketched into the frame on the storyboard cards. During this process of visualization and sketching behavioral objectives were used as a guide line for film content.

Further development to add filming continuity necessitated rewriting the script. During rewriting, descriptive photographic information was entered into the script. The information concerned subject size, camera height, camera and lens movements, and anticipated photographic problems. The revised script
became the shooting script for both films.

The equipment was in operating order and a person trained to act as machine operator. The set was ready and lighting arranged with some help from persons at The Film Production Unit. Several months had passed from the time the equipment was set up until shooting started.

The camera used for shooting was a 16mm Arriflex Model 16 S/B. During the shooting the author acted as director and cameraman. The process of shooting consisted of following the script, directing the machine operator, and then photographing one sequence. Repetition of following the script, directing and photographing continued until all of the scenes had been shot.

Additional footage was shot at varying distances from the subject and from several different angles to insure all of the scenes had been photographed.

The machine operations of inserting and staking by ultrasonics required less than one second from start to finish. To allow the viewer to see this operation slow motion photography was employed.

Slow motion was accomplished by photography with a Hycam high speed camera at 500 frames per second and later projecting the film at 24 frame per second. This stretched the one second realistic time into over 20 seconds screen time.

At this point, all of the exposed Ektachrome Commercial Film was processed. Upon its return from a developing
laboratory the film was visually examined with a hand lens for exposure quality. A copy of this original film footage was optically printed and then developed. The original was then sent to a storage vault and the copy called a workprint was used for editing.

The technique of editing the film involved selecting and arranging the scenes to match the script. After the initial cutting and editing several additional shortening processes eliminated unnecessary footage. For final filmic evaluation the workprint was screened and critiqued by Iowa State University Film Production employees. There were no continuity problems, so the film was considered edited.

Narration for the sound version was written with the idea of using a minimum number of words to support the visual. The behavioral objectives once again served as guidelines. The narration was recorded by a former radio announcer. This audio tape was transferred to 16mm magnetic sound stock. This audio track was then edited to conform to the workprint. For a final evaluation of the intended sound film the sound track and film work print were run simultaneously and in synchronization.

The music for the beginning and ending of the film was selected from the Iowa State University Film Production Unit music library and added to the head and tail of the narration track.

The silent film utilized written statements or titles called overlays. The overlays were abbreviated parts of the
narration which appeared on the screen at appropriate times. Comparison of the narration and overlays will indicate that the same information was presented but the timing varied between them according to what was best for each film.

The production of the overlays was done by photographing printed words on animation paper. The position of the overlay words was determined by projecting the workprint on a Moviola machine. After photographing the printed words this roll of film was edited to conform with the workprint.

At this point there were three rolls of film; the edited workprint, the narration with music, and the silent overlay roll.

The original film footage was then removed from the vault and conformed to the workprint. This original film was cut and spliced into two rolls of film. Each roll contained every other scene with black leader in-between scenes. This conforming was not done by the author, but by a paid film maker. The three rolls of film were used to make the sound and silent films.

The sound track, and two rolls of original film were optically printed to make one roll of film. This roll after processing was the sound film. The overlay roll and the two rolls of original film were optically printed to make one roll of film. This roll after processing was the silent film.

Since this was the author's first film making experience considerable amount of time was spent learning what to do prior the doing it. The production took the author 14 months
of full and part-time work. The cost of materials was $1,800.00.

Film - Sound and Silent

The script like the programmed instruction book followed the behavioral objectives, but not in the same sequence. The first part of the film involved the following:

a. The definition of ultrasonic vibrations.

c. The two methods of metal to plastics assembly.
i. The definition of inserting.
j. Why metal inserts are knurled.
k. Why the premolded or drilled hole is slightly smaller than the insert.
l. Where localized heat is generated with the operation of inserting.
m. Where the vibrations travel with the operation of inserting.
n. The names of parts of the operation of inserting.
o. The vibration phase in the operation of inserting.

The second part of the film introduced by a smooth transition deals specifically with the following:

p. The definition of staking.

q. The names of parts in the operation of staking.
r. The difference between high and low profile in the operation of staking.
s. The vibration phase in the operation of staking.
t. The total length of time needed to assemble metal to plastics parts.

The third part of the film introduced by a smooth transition deals specifically with ultrasonic assembly equipment. The information covered in this section was:

b. The principle upon which ultrasonic assembly is based.
d. The components in the electrical and mechanical system in order of energy flow.
e. The purpose of the electrical and mechanical components.
f. The sequence of energy flow in the electrical and mechanical components.
g. The functions of the power supply, converter, and horn.
h. The normal line voltage outlet, power supply, converter, and horn.

Transparencies

Transparencies like the other instructional materials were produced to meet the behavioral objectives. Key visuals from the programmed book and the films were used for the production of the transparencies. They were designed to show a sequence of events rather than to be used as isolated visuals. In addition, lesson plans were written to accompany the transparencies.

A transparency showing the equipment in oblique view was designed to be used with the following:
d. The components in the electrical and mechanical system in order of energy flow.
e. The purpose of the electrical and mechanical components.
f. The sequence of energy flow in the electrical and mechanical components.
g. The functions of the power supply converter and horn.
h. From an illustration the normal line voltage outlet, power supply, converter and horn.

A sequence of two transparencies showed the operation of inserting. These were designed to be used with the following:
i. The definition of inserting.
j. Why metal inserts are knurled.
k. Why the premolded or drilled hole is slightly smaller than the insert.
l. Where localized heat is generated with the operation of inserting.
m. Where the vibrations travel with the operation of inserting.

A sequence of two transparencies showed the operation of staking. These were designed to be used with the following:
p. The definition of staking.
q. The names of parts in the operation of staking.
r. The difference between high and low profile in the
operation of staking.

s. The vibration phase in the operation of staking.

A portion of the lecture utilized no illustrations. That part of the lecture was to cover the following:

a. The definition of ultrasonic vibrations.
b. The principle upon which ultrasonic assembly is based.
c. The two methods of metal to plastics assembly.

Samples of inserting and staking were used along with the transparency lecture to cover the following:

c. The two methods of metal to plastics assembly.
l. Where localized heat is generated with the operation of inserting.
n. The names of parts in the operation of inserting.
o. The vibration phase in the operation of inserting.
q. The names of parts in the operation of staking.
r. The difference between high and low profile in the operation of staking.
s. The vibration phase in the operation of staking.
METHODS AND PROCEDURES

This study investigated the effectiveness of four instructional methods. Metal to plastics assembly by ultrasonics was the industrial concept taught by the instructional methods.

Selection of the Sample

Selection of the sample consisted of locating industrial arts plastics classes with similar characteristics. The characteristics were: similar industrial plastics curriculum, senior high grade levels, and approximately the same numbers of students per class.

The author had taught industrial plastics at St. Cloud State College, St. Cloud, Minnesota, and was aware that many Minnesota high schools taught industrial plastics and could possibly provide the number of students needed for the study.

A list of schools with industrial plastics classes was provided by the Department of Education, State of Minnesota. From this list eight schools within a 60 mile radius of Minneapolis/St. Paul were contacted. The mileage limitation was established for economic reasons.

Instructors from the eight schools were contacted by letter. In the letter they were asked to describe their course content, number of classes they had, and if they would be willing to participate in the study. From these returns two
schools with identical course content and sufficient numbers of students were chosen. The schools were Park Center Senior High School, and Osseo Senior High School. Both schools are in the Osseo Public School System, Osseo, Minnesota.

Each school had four existing plastics classes. Three each of Plastics I classes and one each of Plastics II classes. The Plastics II classes had not received prior instruction on metal to plastics assembly, and had previously been involved with hand work using thermosetting plastics. This study concerned machines and thermoplastics, so for the purpose of this study all classes were assumed equal in knowledge on metal to plastics assembly.

The assignment of treatments to classes was done by the selection of discs from two boxes. One box contained eight discs identifying the treatments and the other box contained eight discs identifying the classes. The assignments were: T I Park Center period two, and Osseo period two, T II Park Center period three, and Osseo period one, T III Park Center period one, and Osseo period four, T IV Park Center period four, and Osseo period five.

Teaching Design

The four instructional methods of teaching the metal to plastics assembly were presented to the eight industrial plastics classes.

All of the classes were given a mechanical reasoning test and a plastics assembly pretest. Each test was given during a
separate class period.

One school week later the four randomly assigned methods were presented. The programmed instruction book was treatment I (T I). The students worked individually on the instruction books for a total of five class periods. One class period equals 50 minutes. In treatment II (T II) classes the students worked on the programmed instruction books for five class periods and viewed the silent film twice. The classes which received treatment III (T III) worked on the programmed book for five class periods and viewed the sound film twice. The classes assigned treatment IV (T IV) received a transparency lecture method of instruction on metal to plastics assembly. This method also involved five class periods.

One school week after the instructional methods were presented the classes were given a plastics assembly post-test. The test items remained the same as the pretest, but were presented in a different order.

Any student who had missed more than two classes at any time was dropped from the analysis. Students were also dropped if they had not taken the Lorge-Thorndike IQ test.

Preparation of Tests

The pretest and post-test items were prepared by using the behavioral objectives as a guide line. The test items were presented to a group of Iowa State University industrial
education students. An item analysis indicated several poor questions. Rewriting the poor questions and administering the test to a second group of Iowa State University students greatly improved the reliability (.83) of the test items. These items then became the metal to plastics assembly pretest and post-test items. Because of the adjustment in mean scores in the final analysis college age students were used to eliminate poor test items.

Trial Test of Instructional Materials

A tryout of all the instructional materials was conducted by presenting the methods to two Iowa State University plastics classes. There were no serious complications and the instructional materials met with the author's satisfaction.

Teaching Schedules

The teaching schedule utilized five class periods for the presentation of instructional materials and four class periods for the administration of tests and attitude scale.

Mechanical reasoning test day, Thursday 4/6

All students were administered the Mechanical Reasoning Test, Form A, by George K. Bennett, Harold G. Seashore, and Alexander G. Wesman.

Plastics assembly pretest day, Friday 4/7

All students were administered the 41 item pretest on metal to plastics assembly.
Between the mechanical reasoning test day and the plastics assembly pretest day there was a lapse time of five class periods.

First day, Monday 4/17

T I Students worked on the Introduction, Part I, of the programmed instruction book. T II Students worked on Introduction, Part I, of the programmed instruction book. T III Students worked on the Introduction, Part I, of the programmed instruction book. T IV Students received a lecture on the operation of inserting and staking. Samples of inserting and staking were passed around the class.

Second day, Tuesday 4/18

T I Students continued to work on the Introduction, Part I, of the programmed instruction book. If Part I, was completed students were allowed to work on previously started laboratory projects. T II Students viewed the silent film on metal to plastics assembly. If Part I, of the programmed book was completed students were allowed to work on previously started laboratory projects. T III Students viewed the sound film on metal to plastics assembly. If Part I, of the programmed book was completed students were allowed to work on previously started laboratory projects. T IV Students received a review lecture on the operation of inserting and staking. Samples of inserting and staking were passed around the class. Students also received a lecture on the electrical and mechanical system of the equipment.
Third day, Wednesday 4/19

T I Students worked on Inserting and Staking, Part II of the programmed instruction book. T II Students worked on Inserting and Staking, Part II, of the programmed instruction book. T III Students worked on Inserting and Staking, Part II, of the programmed instruction book. T IV Students received a lecture on the operation of inserting.

Fourth day, Thursday 4/20


Fifth day, Friday 4/21

T I Students completed and reviewed the programmed instruction book. T II Students viewed the silent film on metal to plastics assembly and completed the programmed instruction book. T III Students viewed the sound film on metal to plastics assembly and completed the programmed instruction book. T IV Students received a review lecture on the entire concept of metal to plastics assembly by the ultrasonic method.

Post-test day, Monday 5/1

All the students were administered the 41 item post-test on metal to plastics assembly. The test items remained the
same as in the pretest, but were presented in a different order.

Attitude scale day, Tuesday 5/2

All students were asked to record on the attitude scale their feelings toward the instructional method they received.

Statistical Design

The experimental design used in this study was the non-equivalent control design. Since the study utilized intact classes the design was quasi-experimental (5). An illustration of the design for this study is given below. (See Table 2)

Table 2. Experimental design

```
0  X  0
0  X  0
0  X  0
0  X  0
```

0 = measurement
X = experimental treatment

The statistical analysis used in this study was analysis of covariance. The experimental conditions were randomly assigned to the classes. Data were collected from the 99 students in the intact classes. In this study the units involved were classes. Glass and Stanley (7) give an example of this type of analysis when they state:
"Educational researchers are especially prone to making the error of analyzing data in terms of units other than the legitimate experimental unit. Almost all of the comparative experiments carried out under actual school conditions face the same dilemma. At most, no more than five or six intact classrooms have been involved in the experiment. Perhaps pupils have been assigned to classrooms at random, perhaps not. At least, the classrooms have been assigned at random to the experimental conditions being compared. The researcher has two alternatives, though he is seldom aware of the second one: (1) he can run a potentially illegitimate analysis of the experiment by using the "pupil" as the unit of statistical analysis, or (2) he can run a legitimate analysis on the means of the five or six classrooms, "classroom" being the actual experimental unit, in which case he is almost certain to obtain statistically nonsignificant results (with only five or six replications, the power of his significance test is low).

If the researcher chooses the first alternative and is led into error, he can find solace in the knowledge that methodologists themselves have sanctioned his actions either explicitly or by example." (7, p.507)

The author selected alternative number two using an analysis with the classrooms being the experimental unit.

The two tailed F-test at the .05 level of significance was applied to the criterion of metal to plastics assembly achievement. The independent instructional methods were: T I programmed instruction on metal to plastics assembly, T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, and T IV a transparency lecture method of instruction on metal to plastics assembly.

The measures obtained before the presentation of the instruction methods were grade level, mechanical reasoning, verbal IQ scores, nonverbal IQ scores, and metal to plastics
pretest scores.

Covariates

The covariates used in the statistical analysis were: grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics assembly pretest.

The grade level covariate adjusted for any differences in grade level. The plastics classes were not limited to a single grade level (10, 11, or 12). It was for this reason that the grade level covariate was employed.

The mechanical reasoning covariate adjusted for mechanical reasoning abilities. The Mechanical Reasoning Test, For A, by George K. Bennett, Harold G. Seashore, and Alexander G. Wesman was employed.

The verbal IQ covariate adjusted for differences in nonverbal IQ abilities.

The nonverbal IQ covariate adjusted for differences in nonverbal IQ abilities.

The verbal IQ scores and nonverbal IQ scores were obtained from student records. All of the students in the final analysis had taken the Lorge-Thorndike Intelligence Test, Level Four, during their ninth grade.

The metal to plastics assembly covariate was used to adjust for any prior metal to plastics assembly knowledge.
The following analysis of covariance model was used.

\[ Y_{ijk} = u + \beta_1 (X_{aijk} - \bar{X}_a) + \beta_2 (X_{bijk} - \bar{X}_b) + \]
\[ + \beta_3 (X_{cijk} - \bar{X}_c) + \beta_4 (X_{dijk} - \bar{X}_d) + \]
\[ + \beta_5 (X_{eijk} - \bar{X}_e) + \alpha_i + \beta_j + \epsilon_{ij} + \delta_{ijk} \]

\( \beta_1 \) = grade level

\( \beta_2 \) = mechanical reasoning

\( \beta_3 \) = verbal IQ

\( \beta_4 \) = nonverbal IQ

\( \beta_5 \) = metal to plastics assembly pretest

i = 1, 2, 3, and 4

j = 1, 2, 3, ..., 8

k = 1, 2, ..., n_{ij}

u = overall or grand mean

\( X_{aijk} \) = measures on the grade level for the kth student in
the jth class receiving the ith method of instruction.

\( X_{bijk} \) = measures on the mechanical reasoning test for the kth
student in the jth class receiving the ith method of
instruction.

\( X_{cijk} \) = measures on verbal IQ scores for the kth student in
the jth class receiving the ith method of instruction.

\( X_{dijk} \) = measures on nonverbal IQ scores for the kth student
in the jth class receiving the ith method of
instruction.
\( X_{eijk} \) = measures on the pretest scores for the kth student in the jth class receiving the ith method of instruction.

\( \alpha_i \) = the extra effect due to ith method of instruction.

\( \beta_j \) = the extra effect due to the jth class.

\( \varepsilon_{ij} \sim N(0, \sigma^2 \beta_i) \) = the random error in measuring the ith method at the jth class.

\( \delta_{ijk} \sim N(0, \sigma^2) \) = the random error involved in measuring the response of the kth student in the jth class with the ith method of instruction.

Null Hypotheses

The previously mentioned statistical model was used to test the following hypotheses:

1. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between T I programmed instruction on metal to plastics assembly, T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, and T IV a transparency lecture method on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.
2. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T I programmed instruction on metal to plastics assembly, T IV transparency lecture on metal to plastics assembly and the average score from T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

3. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T II programmed instruction plus silent film on metal to plastics assembly, and the average score from T III programmed instruction plus sound film on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

4. There is no significant difference in achievement as measured by the difference in metal to plastics post-
test scores between the average score from T I programmed instruction on metal to plastics assembly, and the average score from T IV a transparency lecture on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

5. There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T I programmed instruction on metal to plastics assembly, T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, and the average score from T IV a transparency lecture method on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.
FINDINGS

This study investigated the effectiveness of several instructional methods. The instructional methods were: T I programmed instruction, T II programmed instruction plus silent film, T III programmed instruction plus sound film, and T IV a transparency lecture method of instruction. The unit of instruction involved assembly of prefabricated parts. Specifically the study concerned itself with metal to plastics assembly.

The four instructional methods were randomly assigned to eight intact industrial plastics classes. Each method was presented to two classes. Four classes at Park Center Senior High School, and four classes at Osseo Senior High School. For the remaining chapters the schools will be referred to as Park Center, and Osseo High respectively. Both schools are in the Osseo Public School System, Osseo, Minnesota.

The data obtained on students before the investigation were grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores. These data were also the covariates.

After the instructional methods were presented the students were given a post-test on metal to plastics assembly. The criterion utilized in this study was achievement gain. Achievement gain was determined by the post-test score on metal to plastics assembly test minus the pretest score on the metal
to plastics assembly test. Data were obtained from 99 students. A total of 20 students were dropped because of absence or lack of complete data information.

A school by method (two-way classification) analysis of covariance was used since each school received one of each of the four treatments. The units of analysis were adjusted means from the eight classrooms. (See Table 3)

Table 3. Adjusted mean gains: Park Center Senior High School, Osseo Senior High School

<table>
<thead>
<tr>
<th>School</th>
<th>T I</th>
<th>T II</th>
<th>T III</th>
<th>T IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park Center</td>
<td>10.4347</td>
<td>14.8073</td>
<td>15.2217</td>
<td>8.2417</td>
</tr>
<tr>
<td>Osseo High</td>
<td>7.8164</td>
<td>7.9439</td>
<td>10.8426</td>
<td>3.2230</td>
</tr>
</tbody>
</table>

Applying the statistical model to the adjusted means to test for a significant difference in instructional methods computed an F value of 12.14. Comparing the computed F value to the table value of 9.28 at the 0.05 level, with appropriate degrees of freedom (3,3) indicated there were significant differences in methods of instruction having statistically adjusted for initial differences in grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores. (See Table 4) Having obtained the significant difference at the 0.05 level the null hypothesis number one is rejected.

Hypothesis number one stated: There is no significant differences in achievement as measured by the difference in
metal to plastics post-test scores minus metal to plastics pretest scores between T I programmed instruction on metal to plastics assembly, T II programmed instruction plus silent film on metal to plastics assembly, T II programmed instruction plus sound film on metal to plastics assembly, and T IV a transparency lecture method on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

Further statistical comparison to isolate the significance was done by comparing films to nonfilm methods (T I, T IV, vs. T II, T III), programmed instruction plus silent film to programmed instruction plus sound film (T II vs. T III), and programmed instruction to transparency lecture (T I vs. T IV).

An F value of 25.56 was computed when testing the comparison of T I programmed instruction, T IV transparency lecture, to T II programmed instruction plus silent film, and T III programmed instruction plus silent film. In Table 4 this was referred to as films vs. nonfilms. Comparing the computed F value (25.56) to the table value of 10.13 at the 0.05 level with appropriate degrees of freedom (1,3) indicated there were significant differences in film vs. nonfilm methods of instruction having statistically adjusted for initial differences in grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores. Having obtained this significant difference in favor of films at the 0.05 level the
Table 4. Analysis of covariance considering methods of instruction (films vs. nonfilms) (sound vs. silent) (programmed instruction vs. transparency lecture) and instructor/or school on class achievement using five covariates

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Residuals</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sums of squares</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Covariates</td>
<td>5</td>
<td>383.45</td>
<td>383.45</td>
</tr>
<tr>
<td>Instructor/or school</td>
<td>1</td>
<td>461.89</td>
<td>461.89</td>
</tr>
<tr>
<td>Method of instruction</td>
<td>3</td>
<td>149.16</td>
<td>149.16</td>
</tr>
<tr>
<td>films vs. nonfilms</td>
<td>1</td>
<td>45.93</td>
<td>45.93</td>
</tr>
<tr>
<td>sound vs. silent</td>
<td>1</td>
<td>21.27</td>
<td>21.27</td>
</tr>
<tr>
<td>programmed instruction vs. transparency lecture</td>
<td>1</td>
<td>4.08</td>
<td>4.08</td>
</tr>
<tr>
<td>Error A, schools x method (among classes)</td>
<td>3</td>
<td>4292.15</td>
<td>49.90</td>
</tr>
<tr>
<td>Error E, residual (among students in classes)</td>
<td>86</td>
<td>54.08</td>
<td>18.03</td>
</tr>
</tbody>
</table>

\[ F(3,3) \quad 0.05 (9.28) \quad F(1,3) \quad 0.05 (10.13) \]

\[ 0.01 (29.46) \quad 0.01 (34.12) \]
null hypothesis number two was rejected.

Hypothesis number two stated: There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T I programmed instruction on metal to plastics assembly, T IV transparency lecture on metal to plastics assembly and the average score from T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

An F value of 2.54 was computed when testing for the comparison of T II programmed instruction plus silent film to T III programmed instruction plus sound film. (See Table 4) Comparing the computed F value (2.54) to the table value of 10.13 at the 0.05 level with appropriate degrees of freedom (1,3) indicated there was no significant difference in silent film vs. sound film having statistically adjusted for initial differences in grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores. Having obtained no significant differences there was insufficient evidence to reject the null hypothesis number three.

Hypothesis number three stated: There is no significant difference in achievement as measured by the difference in
metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T II programmed instruction plus silent film on metal to plastics assembly, and the average score from T III programmed instruction plus sound film on metal to plastics assembly, when the differences between groups are statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

An F value of 8.27 was computed when testing for the comparison of T I programmed instruction to T IV transparency lecture. (See Table 4) Comparing the computed F value of (8.27) to the table value of 10.13 at the 0.05 level of significance with appropriate degrees of freedom indicated there was no significant difference in programmed instruction vs. transparency lecture method having adjusted for initial differences in grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores. Having obtained no significant differences there was insufficient evidence to reject the null hypothesis number four.

Hypothesis number four stated: There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T I programmed instruction on metal to plastics assembly, and the average score from T IV transparency lecture on metal to plastics assembly, when the differences between groups are statistically adjusted
for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

A comparison of error A, school x method vs. instructor/or school indicates there was interaction. A computed F value of 21.27 when compared to the table value of 10.13 at the 0.05 level with appropriate degrees of freedom (1,3) indicates there was significant interaction in error A, school x method when compared to instructor/or school. (See Table 4) The author had assumed at the beginning of the study that the two instructors and schools would be equal, so there was no null hypothesis tested for interaction.

Additional comparison of adjusted means were utilized to further isolate significance.

The comparisons were: programmed instruction book plus silent film to programmed instruction book plus sound film (T II vs. T III), programmed instruction book vs. programmed instruction book plus silent, and programmed instruction plus sound film (T I vs. T II, T III), programmed instruction book, programmed instruction plus silent film, programmed instruction plus sound film vs. transparency lecture (T I, T II, T III, vs. T IV). In Table 5 these were referred to as sound vs. silent, programmed instruction vs. sound and silent, and independent studies vs. teacher lecture respectively.

The comparison on sound vs. silent (T II vs. T III) had been previously computed. (See Table 4)

The comparison of programmed instruction books to programmed
instruction plus silent, and programmed instruction plus sound (T I vs. T II, T III) indicated there were no significant differences at the 0.05 level. (See Table 5)

The comparison of programmed instruction, programmed instruction plus silent film, programmed instruction plus sound film to transparency lecture (T I, T II, T III vs. T IV) indicated there were differences in favor of the independent study methods. A computed F value of 28.31 when compared to a table value of (10.13) at the 0.05 level of significance with appropriate degrees of freedom (1,3) indicated there was a significant difference between the average adjusted means of T I, T II, T III, and the average means of T IV, having statistically adjusted for initial differences in grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores. Having obtained this significant difference at the 0.05 level in favor of independent studies the null hypothesis number five was rejected.

Hypothesis number five stated: There is no significant difference in achievement as measured by the difference in metal to plastics post-test scores minus metal to plastics pretest scores between the average score from T I programmed instruction on metal to plastics assembly, T II programmed instruction plus silent film on metal to plastics assembly, T III programmed instruction plus sound film on metal to plastics assembly, and the average scores from T IV a transparency lecture method on metal to plastics assembly, when the
Table 5. Analysis of covariance considering method of instruction (sound vs. silent) (programmed instruction vs. sound and silent) (independent studies vs. transparency lecture) and instructor/or school on class achievement using five covariates

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Residuals</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sums of squares</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Covariates</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructor/or school</td>
<td>1</td>
<td>383.45</td>
<td>383.45</td>
</tr>
<tr>
<td>Method of instruction</td>
<td>3</td>
<td>656.88</td>
<td>218.98</td>
</tr>
<tr>
<td>sound vs. silent</td>
<td>1</td>
<td>29.32</td>
<td>29.32</td>
</tr>
<tr>
<td>programmed instruction vs. sound and silent</td>
<td>1</td>
<td>108.05</td>
<td>108.05</td>
</tr>
<tr>
<td>independent studies (T I, T II, T III) vs.</td>
<td>1</td>
<td>519.51</td>
<td>519.51</td>
</tr>
<tr>
<td>transparency lecture (T IV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error A, schools x method</td>
<td>3</td>
<td>54.08</td>
<td>18.03</td>
</tr>
<tr>
<td>(among classes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error B, residual</td>
<td>86</td>
<td>4292.15</td>
<td>49.90</td>
</tr>
</tbody>
</table>

\[
F(3,3) 0.05 (2.28) \quad F(1,3) 0.05 (10.13) \\
0.01 (29.46) \quad 0.01 (34.12)
\]
differences between groups were statistically adjusted for grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

Additional data information is contained in Appendix F.
DISCUSSION

The teaching of industrial machine oriented concepts without having the equipment available to students presents a problem to most industrial education teachers. Three effective teaching methods were identified in this study to help solve that problem. The three were programmed instruction, programmed instruction with a silent film, and programmed instruction with a sound film.

Independent Study

There was a significant difference in the adjusted mean gains when comparing independent studies to transparency lecture (T I, T II, T III, vs. T IV). The treatments T I, T II, and T III required no teacher presentations. The students were allowed adequate time to work on the programmed books and in the T II, and T III treatments viewed the film twice. The teacher acted as coordinator of the class and occasionally answered student questions. For the T IV treatment the teacher lectured following the lesson plans and utilized the prepared transparencies.

Because of the error A, school x method, instructor/or school interaction the significant differences could have been misleading. Even though the teachers volunteered their classes the author had no way of knowing the quality of their presentations. There were observable differences in adjusted means
obtained from both schools. However, the unadjusted treatments means that gained the most at Park Center also gained the most at Osseo High.

These findings appear to indicate that if machines are not available for student experimentation teachers should select an alternative to transparency lectures. From the analysis almost any of the independent study methods (T I, T II, or T III) should provide more effective learning.

The programmed instruction book used in the T I treatment was relatively easy to write. It was also inexpensive. One of the problems for industrial education teachers in writing programmed instruction books would be locating sufficient information on the subject. This is assuming the teacher does not have equipment available for experimentation. However, information can easily be obtained by writing to plastics companies. This was how the author obtained his initial information.

An alternative is to work closely with an industry to gain knowledge concerning an industrial concept. Most plastics industries are cooperative with industrial education teachers who seek knowledge on industrial concepts.

The comparison of programmed instruction books alone to films with programmed instruction books indicated there were observable adjusted mean gain differences but no significant differences. This comparison plus the comparison of films to nonfilms appear to indicate the films definitely provided motivation rather than a method of dispensing factual knowledge.
A film with programmed instruction provided a second medium to present the message. The author also felt the film provided motivation to work on the programmed book.

Sound - Silent Films

The data indicated there were little adjusted mean differences between the students who received the sound film treatment over the students who received the silent film treatment.

The cost of a silent film is estimated at being 25% less expensive than a sound film. This is because less equipment, time and personnel are needed, assuming that the same size film is used for the sound and silent film production. If a teacher who practices filming or takes a media class, selects super 8mm for the film size he can produce a silent film for less than $20.00 (excluding equipment).

The author's films using 16mm film size came to $1,800.00 for materials. Had they been produced by a film production company the estimated cost would have been $10,000.00.

An individual teacher could produce a silent 16mm film without too much difficulty. Research has indicated that films photographed by unskilled personnel can be effective (8). In addition optical effects, fades, wipes, and dissolves do not aid in learning over a film with straight cuts (20).

Although very little achievement gain was observed comparing
sound vs. silent film the sound film did add another medium. However, if money and production equipment present a problem remember the gain in the silent film was almost as good as the sound film with a programmed instruction book.

From the data analyzed in the study the indications were that teachers should use independent study materials to teach industrial concepts if equipment is not available to students. Probably not all industrial education teachers feel they have the ability to make films. A solution would be to have teachers work with a film maker. This would insure the production of usable films. The teachers know what they need for their curriculum, and the film maker could photograph and edit the film. The cost of sound films, although it may seem high, is relatively low when you consider the cost per student viewing the film.

The author feels there may have been several reasons for the significant gains. Probably the strongest reason was that the subject matter involved a machine oriented concept and this concept lent itself well to a motion picture film. In addition the slow motion photography allowed the viewer to observe a one second machine operation stretched out to twenty seconds. Another factor involved was that the films added an additional medium to the programmed instruction book. This additional medium may have motivated the student to work in the programmed instruction books while at the same time visualizing the operations of the machine.
From the analysis in this study the conclusion was that any of the three independent study treatments were more effective when teaching a machine oriented concept than transparency lecture.

The attitude scale was administered one day after the post-test. (See Appendix E) It indicated a wide range of student feelings about the study. Students were asked to mark on a scale from zero (strongly disagree) to nine (strongly agree). Neutral feelings were registered at four and five.

The T I classes didn't like the method used to teach the unit. They were divided by school as to whether they could see an advantage in this method of teaching. They didn't find the programmed instruction book method easy to study. They also didn't think they would remember the material.

The T II classes were divided by school on every statement. Park Center was more positive in their responses toward the instructional method.

Treatment T III indicated the most positive attitude toward the method used, students could see an advantage to this method, and found the subject easy to study because of the method of presentation. Moreover, they felt they would remember the information presented.

The positive attitudes of the students receiving the T I, T II, and T III treatments corresponded to the class achievement gains. For example the T III classes had the highest achievement gains also had the most positive attitude toward
their instructional method. The students in the T I, and T II classes indicated there was not enough teacher interaction, but the T III students were less negative toward the independent study system. The narration did provide a "feeling" that was absent in the T I and T II treatments. To alleviate the problem of negative attitude toward the T I and T II treatments one solution would be to provide discussion groups.

The attitudes for T IV were baffling. Students did not like the method, they did not find it easy to study, and they did not think they would remember the material. However, they thought they could see an advantage to teaching by this method.
SUMMARY

This study had direct relationships to industrial education teachers seeking effective ways to teach industrial machine oriented concepts without having equipment available to the students. The study investigated the effectiveness of four teaching methods utilizing instructional materials. The unit of instruction was the concept of metal to plastics assembly.

After the design of the study and working with the assembly equipment behavioral objectives were written to act as guide lines for producing the instructional materials.

For the study the author wrote a 43 page programmed instruction book, wrote, directed, and edited a 10 minute 16mm film in two versions (one sound, one silent) and designed five transparencies with lesson plans.

A linear single response programmed pattern was selected for the programmed instruction book. This book required all students to complete the same items in the same sequence. Validity of the programmed book was established by administering it to college industrial education students.

For the development of the sound and silent versions of the film titled Metal to Plastics Assembly, the author acted as writer, director, and editor. A script was written using the storyboard format. The behavioral objectives were used as a guide for the film content. The film was shot, edited, and then viewed for filmic continuity. Later the sound narration was recorded and added to produce the sound film. The silent version
was developed by photographing words (abbreviated parts of the narration) and optically adding them to the film.

The transparencies like the other instructional materials were produced to meet the behavioral objectives. Key visuals from the programmed book and the films were used for the production of the transparencies. In addition, lesson plans were written to accompany the transparencies.

The four instructional methods were randomly assigned and presented to eight industrial plastics classes. The instructional methods were: T I programmed instruction, T II programmed instruction plus silent film, T III programmed instruction plus sound film, and T IV a transparency lecture method. Each treatment was presented to two classes. There were a total of 99 students in the final analysis. The unit taught was metal to plastics assembly, a machine oriented concept.

The data collected were subjected to analysis of covariance statistical treatment. The criterion was metal to plastics assembly achievement gain. Initial student differences were adjusted for by covarying on grade level, mechanical reasoning, verbal IQ, nonverbal IQ, and metal to plastics pretest scores.

Testing the eight class adjusted means indicated there was a significant difference in instructional methods. This significant difference at the 0.05 level was subjected to further analysis to isolate the significance.

The comparison of nonfilms to films (T I, T IV vs. T II, T III) adjusted means indicated a significant difference in
favor of the films. Both the film treatments also utilized the programmed instruction book.

The comparison of sound films to silent films (T II vs. T III) indicated there was no significant difference.

When testing for the difference in comparing programmed instruction book to transparency lecture (T I vs. T IV) there was no significant difference.

Testing the comparison of independent instruction to transparency lecture (T I, T II, T III vs. T IV) indicated a significant difference at the 0.05 level in favor of the independent study methods.

Student attitudes indicated a wide range of feelings about the study. Although there were no significant achievement differences between the independent study groups, student attitudes were more favorable to T III than to T I, or T II. The T III students could see an advantage to the method, found the subject easy to study because of the method of presentation, and felt they would remember the information presented.
BIBLIOGRAPHY


2. Balzer, Eugene W. Metal to plastics assembly, (motion picture film) Ames, Iowa, Iowa State University Film Production Unit. ca. 1971.


ACKNOWLEDGEMENTS

A word of appreciation is in order to all who helped in carrying out this study. Branson Instruments was most helpful in loaning the ultrasonic assembly equipment and sponsoring the films. A special thanks to all the Iowa State University Film Production Unit staff for technical assistance and cooperation with the production of the films. Those especially involved were Gene Honert, the actor; Ed Rearick, the narrator; Les Benedict, general assistance with the filming; Tom Smith, conforming the original film; Richard Kraemer, pecuniary help; and Steve Knudsen, initial encouragement and guidance.

The author would like to thank Jim Kochevar, Industrial Education Supervisor, Osseo Public School, for making the plastics classes available and for the cooperation with the extra work the study entailed.

The acknowledgements would not be complete without thanking the author's committee for their guidance.

Finally, thank you to my wife Marlys for her understanding, help, and encouragement.
APPENDIX A: PROGRAMMED INSTRUCTION BOOK
Name ___________________________ last first middle
Age _______ Date of Birth __________
Grade ________________
School _________________________
Time of day your class meets _________
Instructor _________________________

METAL TO PLASTICS ASSEMBLY
A Programmed Learning Book
Please read this page carefully.

"Programmed" information is broken down into small, easy to remember units called "frames." Each frame is sequenced in the best way to assure your learning the information it contains and to provide the best basis for understanding each additional new information unit that follows. Most frames require you to write in certain essential information to reinforce the mental processes.

This Programmed Information Book is arranged differently from a conventional textbook. Instead of reading each page completely from top to bottom, you read horizontally from page to page in rows. Each frame is numbered. After reading and answering the top question on the first page, you proceed to the top frame on the second page and so on. When you come to the end of the first horizontal row, go back to the first programmed page and start the second horizontal row. Be sure to fill in every answer.

As you turn each page, you'll see a column on the left side listing the "answers" or information needed to complete the preceding frame. You should be able to supply the missing information without much difficulty. To get the utmost benefit, it's important to remember these points:

- Fill in all blanks in writing, no matter how simple they seem.
- Read the correct answer only after you've written your own - copying will only hinder your learning.
- Complete all frames in sequence; skipping around or looking ahead will also hinder your learning.

As you go through this Programmed Information Book, you'll find that some frames review what you've already learned. Because you'll know this material, writing the information again may seem pointless. However, for maximum retention of what you've learned, it's essential that you write the missing information whenever it's called for.

Some direct information in this Programmed Information Book was provided by Branson Instruments, in a book titled Ultrasonic Assembly (3).
METAL TO PLASTICS ASSEMBLY

Introduction

Part I
Inserting, and staking are two methods of metal to plastics assembly. To assemble the parts, ultrasonic energy is used.

Turn the page and read frame 2.

10. No answer needed

A power supply changes _________ _________ (___) line voltage into _________ cycles per second (Hz.).

20. No answer needed

Inserting, employs the principle of _________ _________ through the application of _________ _________.
1. No answer needed

Ultrasonic energy is mechanical energy in the form of vibrations normally above 15,000 cycles per second. Cycles per second (cps) is also called Hertz (Hz.).

11. 60 cycle per second Hz. 20,000

This high frequency current is then fed into a converter which converts the electrical energy into mechanical energy at 20,000 mechanical cycles per second (Hz.).

21. localized heat high frequency vibrations

The horn passes the ultrasonic vibrations to the metal insert. The insert will vibrate at 20,000 cps, Hz., down to the interface.
<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>No answer needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ultrasonic energy is _______ energy in the form of vibrations above _______ cycles per second, or Hertz.</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>No answer needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The converter converts 20,000 cycles per second (Hz.) electrical energy into mechanical energy at _______ _______ (____).</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>No answer needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The _______ passes the _______ vibrations to the metal insert. The insert will vibrate at _______ cps, Hz, down to the interface.</td>
<td></td>
</tr>
</tbody>
</table>
3. mechanical
18,000

13. 20,000 cycles per second Hz.

23. horn vibrations
20,000

Now define ultrasonic energy:

The converter vibrates in an up and down direction and transfers this motion to an acoustically efficient horn.

In ultrasonic inserting, energy is coupled into the contacted part and carried to the interface where it is released, allowing plastic material to flow.
4. Ultrasonic energy is mechanical energy in the form of vibrations above 18,000 cycles per second Hz.

The thought that ultrasonic energy could be used to join plastic film material was first conceived in the 1940's. Since that time, equipment has been built to develop the principle to the point where rigid thermoplastics can now be "assembled" ultrasonically.

14. No answer needed

The converter vibrates in an _____ ______ direction and transfers this motion to an acoustically efficient ________.

24. No answer needed

In ultrasonic _________, energy is coupled into the contacted part and carried to the __________ where it is released, allowing plastic material to __________.
The principle of ultrasonic assembly can be explained as the conversion of electrical energy into heat energy through high frequency mechanical motion.

As with ultrasonic inserting, ultrasonic staking employs the same principle of creating localized heat through the application of high frequency vibrations.

Now let's review the general principle of ultrasonic assembly. It involves the conversion of electrical energy into heat energy through high frequency mechanical motion. Now list the component parts of the system which makes this possible:

__________________________
In ultrasonic assembly energy is converted into energy through high frequency mechanical motion.

What happens to the ultrasonic vibrations after they leave the horn depends upon which method of assembly is being used.

Ultrasonic staking usually involves the assembly of metal and plastic. It employs localized through the application of vibrations.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. electrical heat</td>
<td>In ultrasonic assembly ________ energy is converted into ________ energy through high frequency ________ motion.</td>
</tr>
<tr>
<td>17. No answer needed</td>
<td>There are four basic methods of ultrasonic assembly: inserting, staking, welding, and swaging.</td>
</tr>
<tr>
<td>27. heat high frequency</td>
<td>In staking, the ultrasonic energy flow is interrupted at the stud, causing ________ to be developed at the point of contact.</td>
</tr>
<tr>
<td>8. electrical heat mechanical</td>
<td>Now, explain the principle upon which ultrasonic assembly is based.</td>
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<td>---------------------------------------------------------------------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>18. No answer needed</td>
<td>List the four basic methods of ultrasonic assembly:</td>
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<td></td>
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<tr>
<td></td>
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</tr>
<tr>
<td>28. heat</td>
<td>In staking, the _____ interrupts the flow of _____, causing _____ to be developed at the point of contact.</td>
</tr>
</tbody>
</table>
Ultrasonic assembly is accomplished by first changing 60 cycle per second (Hz.) line voltage to 20,000 cycles per second (Hz.) by use of a power supply.

List the two methods of ultrasonic assembly you are studying: 
_________________ and_________________.
State the principle of ultrasonic assembly: __________________________
___________________________ 
___________________________ 
___________________________ 
___________________________ 
___________________________
| 30. inserting staking, localized heat through the application of high frequency vibrations | NOW VIEW THE FILM
Metal to Plastics Assembly |
INSERTING AND STAKING

Part II
1. In inserting, a hole is premolded in the plastic slightly smaller in diameter than the insert it is to receive, while a lead section dimensioned to the hole guides the insert into place.

<table>
<thead>
<tr>
<th>14. No answer needed</th>
<th>15. A slight ________ of molten material can usually be tolerated while insufficient interface may result in less than required _________.</th>
</tr>
</thead>
</table>

28. twice stud .5

29. Section view of standard profile
<table>
<thead>
<tr>
<th>1. No answer needed</th>
<th>2. In __________, a hole is premolded in the plastic slightly __________ in diameter than the insert it is to receive.</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. excess strength</td>
<td>16. The choice of contacting the plastic or metal surface with the horn will depend upon the configuration of the part and the ability of the assembly to accept the required vibratory intensity.</td>
</tr>
<tr>
<td>29. No answer needed</td>
<td>30. Section view of __________ profile</td>
</tr>
<tr>
<td>2. inserting smaller</td>
<td>A lead section dimensioned to the hole, guides the _________ into place.</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>16. No answer needed</td>
<td>The choice of contacting the _______ or _______ surface with the _____ depends upon the configuration of the part and the ability of the assembly to accept the required vibratory intensity.</td>
</tr>
<tr>
<td>30. a. 2D standard</td>
<td>The second head-form for staking is called low profile. It produces a diameter 1.5 times the stud diameter with a head height .25 the size of the stud diameter.</td>
</tr>
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<td></td>
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</tr>
<tr>
<td><strong>3. insert</strong></td>
<td>For a final interlocking assembly, the metal insert is usually knurled, undercut, or shaped to resist loads imposed on the finished assembly.</td>
</tr>
<tr>
<td><strong>17. plastic metal horn</strong></td>
<td>In staking, a hole, perhaps in a piece of metal, receives a plastic stud. Staking the plastic requires the release of vibratory energy only at the surface of the plastic stud.</td>
</tr>
<tr>
<td><strong>31. No answer needed</strong></td>
<td><strong>32.</strong></td>
</tr>
</tbody>
</table>

Section view of low profile
5. For a final interlocking assembly, the metal insert is usually ________, ________, or ________ to resist loads imposed on the finished assembly.

19. Melt at this point Vibration at end of horn only Metal or Plastic Plastic

As you can see, in staking, contact area between horn and plastic is as small as possible.

33. Section view of ________ profile
5. **Any Order**
   - knurled
   - undercut
   - shaped

   Ultrasonic vibrations travel through the driven part until they meet the joining area between metal and plastic. At this interface the energy of ultrasonic vibrations is released as heat, permitting the assembly to take place.

19. **No answer needed**

   Label this figure:

   ![Figure]

   - 1.
   - 2.
   - 3.
   - 4.

33. **a. 1.5D low**

   Staking requires that out-of-phase vibrations be generated between the horn and plastic.

34.
6. No answer needed

In inserting, _______ _________ travel through the driven part until they meet the joining area between the _______ and _________ . At this _________ ultrasonic energy is released as _________.

20.

1. vibration at end of horn only
2. plastic
3. metal or plastic
4. melt at this point

In staking, the horn is usually contoured to meet the specific requirements of the application. With the introduction of ultrasonic vibrations, the stud melts and reforms to create a locking head over the metal or plastic.

34. No answer needed

In ultrasonic staking, _______ _________ vibrations are generated between the _______ and _________.

| 7. ultrasonic vibrations | The intensity of heat created by the vibrations between the plastic and the metal is sufficient to melt the ______ momentarily, permitting the ______ to be driven into place. |
| metal | |
| plastic | |
| interface | |
| heat | |

| 21. No answer needed | In staking the horn is usually ______ to meet the requirements of the application. |

<p>| 35. out-of-phase vibrations | Light initial contact is required for out-of-phase vibrations within the limited contact area. Progressive melting of plastic under continuous, but light pressure forms the head. |
| horn | |
| plastic | |
| 8. plastic insert | The intensity of _______ created by the _________ between the plastic and the metal is sufficient to melt the plastic momentarily, permitting the _________ to be driven into place. |
| 22. contoured | With the introduction of ultrasonic vibrations, the stud melts and reforms to create a locking head over the metal or plastic. |
| 36. No answer needed | In ultrasonic staking, out-of-phase _________ and light but continuous _________ forms the head. |</p>
<table>
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<tbody>
<tr>
<td>9. heat vibrations insert</td>
<td><strong>10.</strong> Ultrasonic exposure time is usually less than one second. During this brief contact the plastic reforms itself around knurls, flutes, undercuts, or threads to encapsulate the insert.</td>
</tr>
<tr>
<td>23. No answer needed</td>
<td><strong>24.</strong> With the introduction of ultrasonic vibrations the stud melts and reforms to create a _______ _______ over the _______ or _______.</td>
</tr>
<tr>
<td>37. vibrations pressure</td>
<td><strong>38.</strong> After delivery of energy and material flow, continuous pressure permits establishment of head-form without loosening due to plastic memory.</td>
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</tr>
<tr>
<td>10. No answer needed</td>
<td>Ultrasonic exposure time is usually less than _______. During this brief contact the plastic reforms itself around the knurls, flutes, undercuts or threads to ______ the insert.</td>
</tr>
<tr>
<td>24. locking head metal plastic</td>
<td>There are two head-forms that will satisfy the requirements of most staking applications, standard profile and low profile.</td>
</tr>
<tr>
<td>38. No answer needed</td>
<td>After delivery of _______ and _______ flow, continued _______ permits establishment of head-form without loosening due to plastic memory.</td>
</tr>
</tbody>
</table>
11. one second encapsulate

Insert/hole design will vary with each application, but enough plastic must always be displaced to fill voids created by knurled and undercut areas of the insert.

25. No answer needed

There are _______ head-forms that will satisfy most _________ requirements.
Name them: 1. _________ _________
2. _________ _________

39. energy material pressure
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>In inserting, enough must always be displaced to _______ _______ _______ created by knurled and undercut areas of the insert.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>26. two staking standard profile low profile</th>
<th>27.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The standard head-form produces a head having twice the diameter of the original stud with a height .5 the stud diameter.</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>13. plastic fill the voids</td>
<td>A slight excess of molten material can usually be tolerated while insufficient interface may result in less than required strength.</td>
</tr>
<tr>
<td>27. No answer needed</td>
<td>The standard head-form produces a head having ________ the diameter of the original ________, with a height of ______ the stud diameter.</td>
</tr>
</tbody>
</table>

Go back to page 1, of part II.
ULTRASONIC ASSEMBLY EQUIPMENT
Part III
The component of an ultrasonic system which converts 115 volt, 60 cycle (Hz.) current into 20,000 cycles (Hz.) of electrical energy is the power supply.

15. horn

The purpose of the _____ is to achieve the proper ________ and ________ the part.

30. No answer needed

A programmer with solid state circuitry can control ultrasonic energy exposure as brief as _____ _________.

31
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No answer needed</td>
<td>The _______ _______ converts ______ volt, ______ cycle (Hz.) current into _______ cycles (Hz.) of electrical energy, and does so efficiently and almost instantaneously.</td>
</tr>
</tbody>
</table>

| 16. horn amplitude fit | The horn is tuned to resonate at the system's frequency, and usually measures 1/2 wavelength. |

<p>| 31. .05 seconds | The time program is activated by closing an electrical contact. |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>power supply</td>
<td>Most power supplies operate at either 110 or 220 volts A.C.</td>
</tr>
<tr>
<td>17.</td>
<td>No answer needed</td>
<td>The horn usually measures ______ wavelength. The resonant frequency of the ______ equals the ______ of the system.</td>
</tr>
<tr>
<td>32.</td>
<td>No answer needed</td>
<td>How is the time program activated?</td>
</tr>
</tbody>
</table>
3. No answer needed

A power supply may be rated either in watts or in inch pounds per second output at the tip of the horn.

18. 1/2 horn resonant frequency

The mechanical amplitude of the horn ranges from .001" to .005" at the tip.

33. By closing an electrical contact.

When switching occurs, the programmed cycle is initiated in the programmer and is carried out automatically.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. No answer needed</td>
<td>A power supply may be rated in ______ or in ______ ______ ______.</td>
</tr>
<tr>
<td>19. No answer needed</td>
<td>What is the range of mechanical amplitude at the tip of the horn? ______ to ______.</td>
</tr>
<tr>
<td>34. No answer needed</td>
<td>When _______ occurs, the programmed cycle is initiated in the _______ and is carried out _______.</td>
</tr>
</tbody>
</table>
5. watts
   inch pounds
   per second

The converter functions as an "energy changer" for converting 20,000 cps, Hz electrical energy into 20,000 cps, Hz mechanical energy. The heart of the converter is the transducer.

20. .001"
    .005"

In general practice only a few basic horn shapes are used. The most common are:

- exponential
- step
- catenoidal
- cylindrical
- rectangular

Assembly starts and stops as programmed. The piece is held in position until the molten plastic solidifies. The horn then retracts to a full up position and the cycle ends.
5. No answer needed

The ________ functions as an "energy changer." It changes 20,000 cps, Hz. ________ ________ into 20,000 cps, Hz. ________.

21. No answer needed

Match the following:
1. exponential
2. step
3. cylindrical
c. rectangular
d. ________
5. catenoidal

35. No answer needed

The stand controls the contact of the horn on the part to be assembled. The stand incorporates a pressure device which repeatedly applies a predetermined force through the horn to the part.
<table>
<thead>
<tr>
<th>7. converter electrical energy mechanical energy</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>In an electrostrictive unit, a specially compounded ceramic disc converts electrical to mechanical energy because of its unique properties of expanding and contracting when excited electrically.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>22. 1. c 2. e 3. d 4. a 5. b</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplification can be obtained as desired by the choice of horn design.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>37. No answer needed</th>
<th>38</th>
</tr>
</thead>
<tbody>
<tr>
<td>The stand incorporates a _____ device which applies a predetermined _____ through the _____ to the ___.</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>8. electrical mechanical</td>
<td>In an electrostrictive converter a _______ _______ converts _______ _______ _______ to _______ _______ _______ because of its unique properties of expanding and contracting when excited electrically.</td>
</tr>
<tr>
<td>23. No answer needed</td>
<td>A booster horn can be used between the converter and horn to increase or decrease horn tip amplitude. A booster horn can _______ or _______ horn tip amplitude.</td>
</tr>
<tr>
<td>38. pressure force horn part</td>
<td>Flow control valves are used to control the rate of descent of the horn-converter assembly. What controls rate of descent of the horn-converter assembly? A _______ _______ _______.</td>
</tr>
</tbody>
</table>
9. ceramic disc
   electrical
   energy
   mechanical
   energy

Two types of ceramic compounds have been successful: barium titanate and lead zirconate titanate. Now write the names of these two compounds:

____________________
____________________

24. increase
decrease

A booster horn placed between the
____________________ and the ________ can
____________________ or ______________ horn tip amplitude.

39. flow control
    valve

The stand controls the point at which
the timing cycle is activated and
ultrasonic energy is delivered.
### 10.
<table>
<thead>
<tr>
<th>Choice</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>barium titanate</td>
<td>Two types of ceramic compounds successfully</td>
</tr>
<tr>
<td>lead zirconate</td>
<td>used in converters are _______ _______</td>
</tr>
<tr>
<td>titanate</td>
<td>and _______ _______ _______.</td>
</tr>
</tbody>
</table>

### 25.
- converter
- horn
- increase
decrease

The desired gain is generated by selection of the ratio of the masses.

### 40.
- No answer needed

The _______ controls the point at which the timing cycle is activated and _______ _______ is delivered.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Darium titanate lead zirconate titanate</td>
<td>Lead zirconate titanate can convert electrical energy into mechanical energy with 30% efficiency, dependent on the design.</td>
</tr>
<tr>
<td>26. No answer needed</td>
<td>The programmer or timer turns on the power supply, times the ultrasonics, and maintains pressure until assembly has been completed.</td>
</tr>
<tr>
<td>41. stand ultrasonic energy</td>
<td>Mechanical stops can be incorporated in the stand to improve control of the dimensions of parts.</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>12. No answer needed</td>
<td>__________ __________ can convert electrical energy into mechanical energy with ____% efficiency.</td>
</tr>
<tr>
<td>27. No answer needed</td>
<td>The programmer turns on the ________, times the ________, and maintains ________ until assembly has been completed.</td>
</tr>
<tr>
<td>42. No answer needed</td>
<td>Mechanical stops can be incorporated in the ________ to improve control of the ________ of parts.</td>
</tr>
<tr>
<td>13. lead</td>
<td>The horn, or mechanical impedance transformer may be directly attached to the converter.</td>
</tr>
<tr>
<td>silicate</td>
<td></td>
</tr>
<tr>
<td>titanate 90</td>
<td></td>
</tr>
</tbody>
</table>

<p>| 28. power supply | The programmer has three functions. List them in order. |
| ultrasonics     | 1. __________________________             |
| pressure        | 2. __________________________             |
|                 | 3. __________________________             |</p>
<table>
<thead>
<tr>
<th>14. No answer needed</th>
<th>15. The _______ or mechanical transformer may be directly attached to the converter. Its purpose is to achieve the proper amplitude and fit the part to be assembled.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Go back to page 1, of part III</td>
</tr>
<tr>
<td>29. 1. turns on power supply</td>
<td>With solid state circuitry, weld times as brief as .05 seconds can be controlled accurately.</td>
</tr>
<tr>
<td>2. times ultrasoneics</td>
<td></td>
</tr>
<tr>
<td>3. maintain pressure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Go back to page 1, of part III</td>
</tr>
</tbody>
</table>
APPENDIX B: METAL TO PLASTICS ASSEMBLY
SILENT FILM SCRIPT
OVERLAYS FOR SILENT FILM
INSERTING
encapsulating metal in plastic

STAKING
forming a locking head
hole smaller than insert
vibrating horn
insert
thin molten plastic layer

staking tip contoured to reform plastic
stud melts and is reformed vibrating horn

profile determined by stud size and shape of tip
Power supply converts line frequency to 20,000 Hz.

Piezoelectric element changes electrical signal to mechanical vibrations

20,000 Hz.
.005" maximum movement
adjustable for specific parts
application varies with each product

results depend on materials, design, and application

Note: This film was sponsored by Branson Instruments
APPENDIX C: METAL TO PLASTICS ASSEMBLY
SOUND FILM SCRIPT
Inserting and staking are two methods of metal to plastics assembly.
Inserting, is encapsulating metal in thermoplastic.

Staking, is reforming a plastic stud to create a locking head.

For both inserting and staking, ultrasonic energy in the form of vibrations is applied to the parts through the horn.

With inserting, the hole is drilled or premolded slightly smaller than the metal insert.
Shown in slow motion, the vibrations from the horn travel through the metal insert.
At the point where the insert and plastic come in contact, the friction causes the plastic to melt momentarily, permitting the insert to be driven into place.

The plastic reforms itself around the flutes causing a permanent fusion of plastic to metal.

The parts remain cool because heat is generated only at the insert to plastic interface.

For staking, a specially designed horn is attached to the machine.

The locking head will conform to the contoured tip.

The height and width of the stud, and the shape of the horn tip determine the final profile.
Shown in slow motion, the horn contacts the stud.

Localized heat generated by the vibrations causes the plastic to melt and reform.
To operate the machine, a solid state power supply converts normal line frequency into 20,000 cycles per second amplified signal.

This signal is fed into an electrostrictive converter.

The piezoelectric element in the converter changes the signal into 20,000 mechanical vibrations per second.

The titanium horn is tuned to resonate at this frequency, with a maximum movement of five thousandths of an inch.
Pneumatic cylinders inside the stand provide power for the gross up and down movement of the horn.

Pressure,

duration of hold time,

and weld time can be adjusted for the specific parts being assembled.

This program is activated by closing an electrical contact.
The application of ultrasonic plastics assembly varies with each product.

Final results depend on materials, critical design, and technical application to the product.

Note: This film was sponsored by Branson Instruments
APPENDIX D: TRANSPARENCY LECTURE
LESSON PLANS AND
TRANSPARENCY ORIGINALS
Lesson Plan for Monday 4/17

Lesson Title: Inserting and Staking

- Define ultrasonic vibrations and how they are used in industry.

- Explain that this week's lectures will be on two methods of metal to plastics assembly.

- Define inserting.

- Explain inserting. .. pass around the samples of inserting.

- Define staking.

- Explain staking. .. pass around the samples of staking.

- Questions and answers.
Lesson Plan for Tuesday 4/18

Lesson Title: Inserting and Staking Review

Electrical and Mechanical Equipment

- Review the definition of ultrasonic vibrations and how they are used in industry.
- Review the definition of inserting.
- Explain inserting... examine the samples.
- Review the definition of staking.
- Explain staking... examine the samples.
- Questions and answers.

- Explain the following components: power supply, converter, and horn.

- Explain the functions of each of the components in the electrical mechanical system.
Lesson Plan for Wednesday 4/19

Lesson Title: Inserting

- Define inserting.
- Identify the parts of the inserting operation.

Transparency

- Explain the inserting operation from start to finish.

Transparencies

- Identify the location of localized heat.
- Questions and answers.
Lesson Plan for Thursday 4/20

Lesson Title: Staking

- Define staking.
- Identify the parts of the staking operation.

Transparency

- Explain the staking operation from start to finish.

Transparencies

- Identify the location of localized heat.
- Questions and answers.
Lesson Plan for Friday 4/21

Lesson Title: Metal to Plastics Assembly

- Define ultrasonic vibrations.
- Explain that inserting and staking are two methods of metal to plastics assembly. Use the samples of inserting and staking.
- Explain the components in the electrical mechanical system in the order of energy flow. Use the transparency illustrating the assembly equipment.
- Define inserting.
- Identify the parts in the inserting operation.
- Explain the inserting operation.
- Identify the location of localized heat.
- Define staking.
- Identify the parts in the staking operation.
- Explain the staking operation.
- Identify the location of localized heat.
- Review the entire sequence of events for both operations by starting with the flow of energy to the parts being assembled.
APPENDIX E: METAL TO PLASTICS
PRETEST, POST-TEST
AND ATTITUDE SCALE
METAL TO PLASTICS ASSEMBLY PRETEST

DIRECTIONS: Read each question and its numbered answers. When you have decided which answer is correct, blacken the corresponding space on the answer sheet with a No. 2 pencil. Make your mark as long as the pair of lines, and completely fill the area between the pair of lines. If you change your mind, erase your first mark completely. Make no stray marks, they may count against you.

1. Inserting and staking are two methods of
   1. plastics molding
   2. plastics decorating
   3. metal to plastics assembly
   4. metal to metal assembly

2. Ultrasonic energy is mechanical energy in the form of vibrations normally above
   1. 14,000 cps. Hz.
   2. 16,000 cps. Hz.
   3. 22,000 cps. Hz.
   4. 26,000 cps. Hz.

3. In staking, a locking head is created by melting and reforming the
   1. interface
   2. metal
   3. insert
   4. stud

4. The components of the electrical and mechanical system in order of energy flow is
   1. power supply, horn, converter
   2. converter, power supply, horn
   3. power supply, converter, horn
   4. horn, power supply, converter
5. The purpose of the converter is to
   1. change mechanical energy into electrical energy
   2. change electrical energy into mechanical energy
   3. increase the electrical cycles
   4. transfer mechanical energy to the parts being assembled

6. The principle upon which ultrasonic assembly is based is
   1. heat energy converted into electrical energy by high frequency mechanical motion
   2. electrical energy converted into heat energy by high frequency mechanical motion
   3. electrical energy converted into heat by electrical resistance
   4. high frequency mechanical motion converted into heat

7. In staking, the horn is
   1. outlined to meet the application
   2. contoured to meet the application
   3. stressed to meet the application
   4. knurled to meet the application

8. In staking the final profile is determined by
   1. type of plastic, and the shape of the horn tip
   2. size of stud
   3. number of vibrations and size of stud
   4. height and width of the stud, and the shape of the horn tip

9. The two methods of metal to plastics assembly studied in this unit are
   1. inserting and swaging
   2. staking and welding
   3. welding and swaging
   4. inserting and staking
10. The definition of inserting is
   1. reforming an insert to create a locking head
   2. reforming a plastic stud to create a locking head
   3. encapsulating metal in thermosetting plastics
   4. encapsulating metal in thermoplastics

11. The definition of staking is
   1. reforming an insert to create a locking head
   2. reforming a plastic stud to create a locking head
   3. encapsulating metal in thermosetting plastics
   4. encapsulating metal in thermoplastics

12. Knurling on metal inserts is used to
   1. guide the insert
   2. provide for fast assembly
   3. absorb heat during assembly
   4. provide an interlocking assembly

13. The time that ultrasonic energy is applied to the parts being assembled is less than
   1. one second
   2. two seconds
   3. three seconds
   4. four seconds

14. In inserting a hole is premolded or drilled in the plastic
   1. slightly smaller than the insert
   2. the same size as the insert
   3. slightly larger than the insert
   4. a lot smaller than the insert

15. In inserting localized heat is generated only at
   1. the contact between the parts being assembled and the base of the machine
   2. the contact between the horn and insert
   3. the contact between the horn and stud
   4. the metal to plastic interface
16. Identify this illustration of a staking profile

1. standard profile
2. low profile
3. extreme low profile
4. extreme high profile

17. In the illustration, vibrations from the horn create localized heat at

1. point A
2. point B
3. point C
4. point D

18. Identify this illustration of staking profile

1. standard profile
2. low profile
3. extreme low profile
4. extreme high profile
19. Identify item A in this illustration

1. horn  
2. power supply  
3. converter  
4. normal line voltage outlet

20. Identify item B in the above illustration

1. horn  
2. power supply  
3. converter  
4. normal line voltage outlet

21. Identify item C in the above illustration

1. horn  
2. power supply  
3. converter  
4. normal line voltage outlet

22. Identify item D in the above illustration

1. horn  
2. power supply  
3. converter  
4. normal line voltage outlet

23. In staking localized heat is generated only at

1. the contact between the parts being assembled and the base of the machine  
2. the contact between the horn and insert  
3. the contact between the horn and stud  
4. the metal to plastic interface
24. In the illustration, vibrations from the horn
   1. travel through the plastic stud
   2. are stopped at the insert
   3. vibrate at the contact between the horn and insert
   4. travel through the metal insert

25. In the illustration the flow of energy is from
   1. A-B-C-D
   2. B-C-D-A
   3. D-B-C-A
   4. D-A-B-C

26. In the illustration, vibrations from the horn travel to
   1. point A
   2. point B
   3. point C
   4. point D
27. Identify item A in this illustration of staking

1. plastic
2. metal or plastic
3. melt at this point
4. horn

28. Identify item B in the above illustration of staking

1. plastic
2. metal or plastic
3. melt at this point
4. horn

29. Identify item C in the above illustration of staking

1. plastic
2. metal or plastic
3. melt at this point
4. horn

30. Identify item D in the above illustration of staking

1. plastic
2. metal or plastic
3. melt at this point
4. horn
31. The maximum movement of the horn is

1. .005" 
2. .050" 
3. .500" 
4. 5.00"

32. To satisfy the requirements of most staking applications there are how many head-forms?

1. one 
2. two 
3. three 
4. four

33. Staking requires what kind of vibrations between the horn and plastic?

1. out-of-phase 
2. in-phase 
3. two-phase 
4. three-phase

34. What is the name of the component which changes 115 volt 60 cps. Hz. current into 20,000 cps. Hz. electrical energy?

1. power supply 
2. piezoelectric element 
3. horn 
4. converter

35. What is the name of the component which changes 20,000 cps. Hz. electrical energy into 20,000 cps. Hz. mechanical energy?

1. power supply 
2. insert 
3. horn 
4. converter

36. The component connected below the converter is the

1. power supply 
2. insert 
3. horn 
4. converter
37. Identify item A in this illustration of inserting
   1. plastic
   2. horn
   3. insert
   4. interface

38. Identify item B in the above illustration of inserting
   1. plastic
   2. horn
   3. insert
   4. interface

39. Identify item C in the above illustration of inserting
   1. plastic
   2. horn
   3. insert
   4. interface

40. Identify item D in the above illustration of inserting
   1. plastic
   2. horn
   3. insert
   4. interface

41. The purpose of the power supply is to change normal line voltage into
   1. increased mechanical energy
   2. decreased mechanical energy
   3. increased electrical cycles
   4. decreased electrical cycles
METAL TO PLASTICS ASSEMBLY POST-TEST

DIRECTIONS: Read each question and its numbered answers. When you have decided which answer is correct, blacken the corresponding space on the answer sheet with a No. 2 pencil. Make your mark as long as the pair of lines, and completely fill the area between the pair of lines. If you change your mind, erase your first mark completely. Make no stray marks, they may count against you.

1. The definition of staking is
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   3. encapsulating metal in thermosetting plastics
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   1. 14,000 cps. Hz.
   2. 16,000 cps. Hz.
   3. 22,000 cps. Hz.
   4. 25,000 cps. Hz.

7. The principle upon which ultrasonic assembly is based is
   1. heat energy converted into electrical energy by high frequency mechanical motion
   2. electrical energy converted into heat energy by high frequency mechanical motion
   3. electrical energy converted into heat by electrical resistance
   4. high frequency mechanical motion converted into heat

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   1. guide the insert
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   3. absorb heat during assembly
   4. provide an interlocking assembly

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   1. one second
   2. two seconds
   3. three seconds
   4. four seconds
10. In inserting a hole is premolded or drilled in the plastic

1. slightly smaller than the insert
2. the same size as the insert
3. slightly larger than the insert
4. a lot smaller than the insert

11. In inserting localized heat is generated only at

1. the contact between the parts being assembled and the base of the machine
2. the contact between the horn and insert
3. the contact between the horn and stud
4. the metal to plastic interface

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1. interface
2. metal
3. insert
4. stud

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1. power supply, horn, converter
2. converter, power supply, horn
3. power supply, converter, horn
4. horn, power supply, converter

14. The purpose of the converter is to

1. change mechanical energy into electrical energy
2. change electrical energy into mechanical energy
3. increase the electrical cycles
4. transfer mechanical energy to the parts being assembled

15. Inserting and staking are two methods of

1. plastics molding
2. plastics decorating
3. metal to plastics assembly
4. metal to metal assembly
16. Identify this illustration of a staking profile

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2. low profile
3. extreme low profile
4. extreme high profile

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1. point A
2. point B
3. point C
4. point D

18. Identify this illustration of staking profile

1. standard profile
2. low profile
3. extreme low profile
4. extreme high profile
19. Identify item A in this illustration of inserting

1. plastic
2. horn
3. insert
4. interface

20. Identify item B in the above illustration of inserting

1. plastic
2. horn
3. insert
4. interface

21. Identify item C in the above illustration of inserting

1. plastic
2. horn
3. insert
4. interface

22. Identify item D in the above illustration of inserting

1. plastic
2. horn
3. insert
4. interface

23. The purpose of the power supply is to change normal line voltage into

1. increased mechanical energy
2. decreased mechanical energy
3. increased electrical cycles
4. decreased electrical cycles
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1. .005"
2. .050"
3. .500"
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3. three
4. four

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2. in-phase
3. two-phase
4. three-phase

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2. insert
3. horn
4. converter

29. The component connected below the converter is the
1. power supply
2. insert
3. horn
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   1. travel through the plastic stud
   2. are stopped at the insert
   3. vibrate at the contact between the horn and insert
   4. travel through the metal insert

31. In the illustration the flow of energy is from
   1. A-B-C-D
   2. B-C-D-A
   3. D-B-C-A
   4. D-A-B-C

32. In the illustration, vibrations from the horn travel to
   1. point A
   2. point B
   3. point C
   4. point D
33. **Identify item A in this illustration of staking**

1. plastic
2. metal or plastic
3. melt at this point
4. horn

34. **Identify item B in the above illustration of staking**

1. plastic
2. metal or plastic
3. melt at this point
4. horn

35. **Identify item C in the above illustration of staking**

1. plastic
2. metal or plastic
3. melt at this point
4. horn

36. **Identify item D in the above illustration of staking**

1. plastic
2. metal or plastic
3. melt at this point
4. horn
37. Identify item A in this illustration

1. horn
2. power supply
3. converter
4. normal line voltage outlet

38. Identify item B in the above illustration

1. horn
2. power supply
3. converter
4. normal line voltage outlet

39. Identify item C in the above illustration

1. horn
2. power supply
3. converter
4. normal line voltage outlet

40. Identify item D in the above illustration

1. horn
2. power supply
3. converter
4. normal line voltage outlet

41. In staking localized heat is generated only at

1. the contact between the parts being assembled and the base of the machine
2. the contact between the horn and insert
3. the contact between the horn and stud
4. the metal to plastic interface
STUDENT ATTITUDE SCALE

School ____________________  Instructor ________________

Class Hour _________________

This scale has been prepared so that you can indicate how you feel about the Metal to Plastics Assembly Learning Unit. Below each statement is a number, circle the number according to how you feel about the statement.

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1. I liked the method used in teaching this unit.
   0 1 2 3 4 5 6 7 8 9

2. There was not enough contact between teacher and students in this unit.
   0 1 2 3 4 5 6 7 8 9

3. I can see an advantage to this method of teaching over other methods.
   0 1 2 3 4 5 6 7 8 9

4. Some students benefited more than others from this type of teaching unit.
   0 1 2 3 4 5 6 7 8 9

5. I found it easy to study the subject because of the method used to present it.
   0 1 2 3 4 5 6 7 8 9

6. Students did not participate enough in this unit.
   0 1 2 3 4 5 6 7 8 9
7. All classes should employ the method used to teach this unit.

8. Too much emphasis has been placed on a unit that is unimportant.

9. I feel I will remember the material in this unit because of the method used to present it.

10. The method of instruction used in this class could be improved.

11. The material was well organized.

12. The subject matter of this unit was not interesting.

COMMENTS:
APPENDIX F: STUDENT DATA, CLASS DATA, AND SCHOOL DATA
Table 6. Student data: Park Center Senior High School T I programmed instruction book

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Table 8. Student data: Park Center Senior High T II programmed instruction book plus silent film

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Table 10. Student data: Park Center Senior High School T III programmed instruction plus sound film

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Table 14. Comparison of means and standard deviations: Park Center Senior High School

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Table 15. Comparison of means and standard deviations: Osseo Senior High School

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Table 16. Comparison of achievement gain means and adjusted gain means: Park Center Senior High School

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Table 17. Comparison of achievement gain means and adjusted gain means: Osseo Senior High School

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