A study of the different types of plastics to ascertain their suitability as a material in the construction of projects in industrial arts programs.

Approved:

[Signatures]

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A STUDY OF THE DIFFERENT TYPES OF PLASTICS TO
ASCERTAIN THEIR SUITABILITY AS A MATERIAL
IN THE CONSTRUCTION OF PROJECTS IN
INDUSTRIAL ARTS PROGRAMS

THESIS

Presented to the Graduate Council of the
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For the Degree of

MASTER OF SCIENCE

By

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Since the beginning of time, man has continued to seek ways of doing new things, better ways of doing old things, and new ways of remaking the materials of nature. Steadily progressing, he has devised many new tools and materials to help him in his daily mode of life. There was a time when industry gave little attention to the aesthetic side of life in the manufacturing of articles. More recently, however, beauty and design are claiming their share of attention in industrial planning and manufacture of articles. During the early development of plastics, they were judged in terms of how well they imitated natural materials that were regarded as beautiful and valuable, such as ivory, onyx, and pearl. But now there has come a realization that plastics are beautiful and useful, not merely because they resemble more expensive materials, but because they possess beauty and usefulness in their own right.

Today, many schools include plastics in classes involving craftwork, and many amateur craftsmen are fashioning articles by hand and by machine from these colorful, gem-like materials. The growth of the plastics industry has been so rapid that many of the industrial arts teachers
and the general public are not aware of the many sources of
information on the different types of plastics, their charac-
teristics, and their proper uses.

Purpose of the Study

The purpose of this study is actually eightfold: first,
to present a review of the literature and information avail-
able concerning plastics needed to ascertain the growth of
the plastic industry and the uses of plastics in general;
second, to present data and information found to be avail-
able with respect to the various types of plastics available
for use in industrial arts programs; third, to devise ways
and means and/or to develop criteria that may be used as a
guide by industrial arts teachers to help them in the selec-
tion of plastics that are suitable for use as a material in
the construction of projects in industrial arts; fourth, to
study the information and data available concerning the var-
ious types of plastics available to determine what types
are better suited as materials to be used in construction
of projects by students enrolled in industrial arts courses;
fifth, to offer suggestions and ideas with respect to plan-
ning an industrial arts laboratory suitable for students
working with plastics; sixth, to offer suggestions concern-
ing the development of units of learning involving plastics;
seventh, to compile a list of dealers who cater to the sell-
ing of plastics to industrial arts programs and to home
craftsmen; eighth, to compile a list of supply houses and dealers in plastics from whom instructional materials such as folders, pamphlets, charts, and brochures describing plastics and their uses may be obtained for use in the teaching of plastics.

Source of Data

The data and information for this study were obtained in the main from materials supplied by some forty manufacturing plants, fabricators, and suppliers of plastics who were contacted. Some data and information were secured from textbooks, magazines, brochures, and pamphlets. Some of the information was secured from actual laboratory experience and tests.

Limitations of the Study

This study will not attempt to analyze the various types of plastics presented with respect to the chemical ingredients and chemical processes necessary for their manufacture, but it will deal primarily with the selection and use of the various types of plastics as materials suitable for use in the construction of projects in an industrial arts program. The study is further limited in that only those plastics listed in the catalogues of business firms catering to the selling of plastics to schools and home craftsmen will be treated. No attempt will be made to
analyze each of the thirty types and 672 trade names as reported by James in a study conducted in 1951.¹

Definition of Terms

The term "plastic" has been defined in many different ways. Webster defined it as a material "capable of being formed or molded";² this definition, however, is too general for the purposes of this study. In order to exclude such natural plastics as clay, pitch, and shellac, a definition presented by the Society of the Plastic Industry will be used.

... a plastic is: Any one of a large and varied group of materials which consists of, or contains as an essential ingredient a substance of high molecular weight and which while solid in the finished state, at some stage in its manufacture has been or can be formed into various shapes by flow usually through application singly or together of heat and pressure.³

"Analysis" as used in this study pertains to the study or testing of the characteristics of each type of plastic presented by a standard or criteria.

The term "use or probable use" refers to what extent a plastic may qualify as a material suitable for use in constructing projects in an industrial arts shop.


"Availability" refers to the ease with which plastic materials can be purchased on the commercial market by the average industrial arts teacher.

The term "type of plastic" refers to a particular kind of plastic, such as Plexiglas or Lucite, and does not necessarily refer to the chemical composition of any of the plastics mentioned.

Organization of the Study

Chapter I contains an introduction to the problem, the purpose of the study, the limitations of the study, sources of data and information, definition of terms, the organization of the study, and some recent and related studies.

Chapter II presents a short history of plastics and their development; it also explains some of the early uses as well as present-day uses of plastics.

Chapter III contains criteria which were developed for use in analyzing the various plastics presented and treated in this study to determine their uses or probable uses as materials suitable for use in the construction of projects in industrial arts programs and an evaluation of the various types of plastics presented in the study.

Chapter IV contains suggestions concerning the planning and equipping of an industrial arts laboratory in which courses involving plastics are taught. Suggestions are made
concerning the development of units of learning around plastics and the plastics industry.

The study is briefly summarized in Chapter V, and the conclusions and recommendations based on the results of the study are set forth.

Recent and Related Studies

There have been several research studies conducted and several books published concerning plastics, their development and their use in industry and in industrial arts programs. A. S. James made a study of the development and use of plastics in industry in 1951 in partial fulfillment of the requirements for the Master's Degree at North Texas State College, Denton, Texas. James' study was limited to the development and use of plastics in the United States, with the exception of a treatment of the origin and early development of plastics in Europe. He gave an extensive treatment of the origin and early development in the United States and stated that there were 30 different types of plastics and 672 trade names used in the plastics industry.\(^4\)

An extensive treatment was given concerning the uses of plastics in the electrical, chemical, automotive, and architectural industries. Some of the various uses of plastics by the individual consumer were treated, such as the use of

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\(^4\)James, op. cit., p. 91.
plastics in the kitchen and bathroom and for upholstery and floor coverings.

James stated that there was a need for adaptation of work with plastics as a phase of industrial arts and listed some proposals or ways and means of adapting plastics to industrial arts programs. The types of plastics treated by James were Tenite, Catalin, the Bakelite cast resins, and Castolite. He did not indicate in his study, however, whether or not these types of plastics were readily available to industrial arts teachers, nor whether or not any one of the aforementioned types possessed qualities that would make it more desirable than other types presented as a material for use in industrial arts programs.

James concluded that there were a number of plastics that could be used in industrial arts programs, but he did not give the name or trade name for them, nor did he give any suggestions that might be of value to an industrial arts teacher in the selection of the various types of plastics. He recommended that plastics should be used in the junior high school industrial arts shops where emphasis is on hand work rather than on machine work and that laminates should be introduced into woodworking classes to be used in furniture making and other applications for which they are particularly suited.

Emma L. Sealy made a study on the subject of plastics in 1946 and presented a summary of the history of plastics,
as well as some of the trade names and a possible use of each type. This study also contained a discussion of the chemical components and processes used in manufacturing plastics.  

One of the earlier books to be published and recommended as being suitable as a textbook on the use of plastics in industrial arts courses and homemaking work is entitled General Plastics by Raymond Cherry. Cherry devotes the first portion of this publication to a brief description of the different types of plastics, but he does not give any information as to which plastics would be of value for use in industrial arts work. In Section II of the book, he presents the fundamental operations, such as layout work, cutting stock to size, squaring stock, and others. Section III lists forty-two projects, with the steps of procedure, and a set of plans for each of the projects.

Another book which pertains to plastics and their possible use in industrial arts is by A. J. Lockrey and is entitled Plastics in the School and Home Workshop. Lockrey gives a brief history of plastics and follows this with a description of each type of plastic, but again one fails to find any information as to which type of plastic might be

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6Raymond Cherry, General Plastics.
superior to another one for use in an industrial arts course. The main topics treated in this book are equipment required for working with plastics, machining operations, carving, forming, cementing, and the finishing processes. There is some information presented concerning the molding of plastics, as well as some projects made with acetate, Lucite, and Plexiglas.

Chris H. Groneman published a book on the use of plastics, but he also failed to analyze the different types of plastics as to which one might prove the most suitable as a material for use in an industrial arts shop. Groneman divided his material into four parts. The first part is called "General Information" and contains a definition of plastics, a discussion on the molding of plastics, the principal classes of plastics, and the essential tools and equipment required for working with plastics. The second part of the book treats the processes for working plastics which include layout, sawing, polishing, turning, drilling, tapping and threading, forming, fastening, decorating, cleaning, and coloring. The third and fourth parts of the book are devoted to projects and special designs in plastics, in that order.

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7A. J. Lockrey, Plastics in the School and Home Workshop.

8Chris H. Groneman, Plastics Made Practical.
CHAPTER II

THE ORIGIN AND DEVELOPMENT OF THE

PLASTICS INDUSTRY

The plastics industry is a relatively new field, yet it has grown to tremendous proportions in the last ten or fifteen years. The actual value of plastics to America during World War II will probably never be known, because there is no way to measure this value in dollars and cents. Just prior to World War II, there was probably much misinformation made available to the public about plastics and how they would change the world overnight. Many people believed these statements, but when proof of this change was not established, the general public lost faith in the ultimate value of this new product. Since then, however, the plastics industry can present some evidence to back up all previous claims, but the public is still skeptical and critical. At the present, however, this field of industry is more firmly established, and it should be but a matter of time before the public will more than likely accept its value.

Origin of the Plastics Industry

The plastics industry had its origin in the earlier half of the nineteenth century in Europe. Braconnor of France and
Schoenbien of Switzerland did extensive research with the first thermoplastic between 1833 and 1845. The research that they conducted was not used commercially until about 1870. At this time, there was a shortage of ivory, and the scientists were striving to find a substitute for it. John Wesley Hyatt, a printer's apprentice, quite by accident found that a bottle of collodion had spilled and that there was a hard, solid skin left on the shelf where it had spilled. Recognizing the possibility of the skin left on the shelf as a result of spilling collodion, he and his brother began experimenting and finally discovered what is now known as celluloid. The Hyatt brothers formed a company in 1872 and started what is now known as the Celanese Plastics Corporation. The first thermosetting plastic was discovered in 1909 when Leo H. Baekeland announced a phenol-formaldehyde resin which later became known as Bakelite.¹

The first casein plastic was introduced on a commercial basis in 1919.² It was at this point that the infant plastics industry began to grow and to expand to its present size. Some of the different types of plastics that have been developed and which are used at the present time are cellulose, acetate, the vinyls and acrylics, urea-formaldehyde, phenol-formaldehyde, cellulose nitrate, cellulose butyrate, ethyl cellulose, and nylon.

¹J. H. Dubois, Plastics, p. 2.
²Chris H. Groneman, Plastics Made Practical, p. 2.
Table 1 shows the compounds of the various types of plastics, the date of discovery, and an example of the various articles made from each.

TABLE 1
MAJOR COMPOUNDS OF PLASTICS, DATE OF DISCOVERY, AND AN EXAMPLE OF EACH*

<table>
<thead>
<tr>
<th>Date</th>
<th>Material</th>
<th>Example of Common Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1868</td>
<td>Cellulose Nitrate</td>
<td>Eye Glass Frames</td>
</tr>
<tr>
<td>1909</td>
<td>Phenol-Formaldehyde</td>
<td>Telephone Hand Set</td>
</tr>
<tr>
<td>1909</td>
<td>Cold Molded</td>
<td>Knobs and Handles</td>
</tr>
<tr>
<td>1919</td>
<td>Casein</td>
<td>Knitting Needles</td>
</tr>
<tr>
<td>1926</td>
<td>Alkyds</td>
<td>Electrical Bases (molded)</td>
</tr>
<tr>
<td>1926</td>
<td>Aniline-Formaldehyde</td>
<td>Terminal Boards</td>
</tr>
<tr>
<td>1927</td>
<td>Cellulose Acetate</td>
<td>Toothbrushes, Packaging</td>
</tr>
<tr>
<td>1929</td>
<td>Urea-Formaldehyde</td>
<td>Lighting Fixtures</td>
</tr>
<tr>
<td>1931</td>
<td>Acrylic</td>
<td>Brush Backs, Displays</td>
</tr>
<tr>
<td>1932</td>
<td>Cellulose Acetate Butyrate</td>
<td>Irrigation Pipe</td>
</tr>
<tr>
<td>1935</td>
<td>Ethyl Cellulose</td>
<td>Flashlight Cases</td>
</tr>
<tr>
<td>1936</td>
<td>Polyvinyl Chloride</td>
<td>Raincoats</td>
</tr>
<tr>
<td>1936</td>
<td>Polyvinyl Acetate</td>
<td>Flash Bulb Lining</td>
</tr>
<tr>
<td>1938</td>
<td>Polystyrene or Styrene</td>
<td>Kitchen Housewares</td>
</tr>
<tr>
<td>1938</td>
<td>Nylon (Polymides)</td>
<td>Gears</td>
</tr>
<tr>
<td>1938</td>
<td>Polyvinyl Acetate</td>
<td>Safety Glass Interlayer</td>
</tr>
<tr>
<td>1939</td>
<td>Melamine-Formaldehyde</td>
<td>Tableware</td>
</tr>
<tr>
<td>1939</td>
<td>Polyvinylidene Chloride (Saran)</td>
<td></td>
</tr>
<tr>
<td>1942</td>
<td>Polyethylene or Polythene</td>
<td>Auto Seat Covers</td>
</tr>
<tr>
<td>1942</td>
<td>Polysters</td>
<td>Squeezable Bottles</td>
</tr>
<tr>
<td>1943</td>
<td>Silicones</td>
<td>Interior Partitions</td>
</tr>
<tr>
<td>1943</td>
<td>Polyfluoroethylene</td>
<td>Motor Insulation</td>
</tr>
</tbody>
</table>


Uses of Plastics Now and Later

Plastics will probably never completely take the place of wood or metal. However, with the decreasing supply of many of the raw materials and the constant research being
made by scientists for the development of lighter and sturdier materials, plastics are being adapted to many industrial uses.

Figure 1 is an illustration of one of the many uses being made of plastics today. This illustration shows two classrooms designed by some plastics engineers. The features and fixtures shown in the illustration have been tested scientifically, and the plastics industry emphasizes that this type of building could be built today. The attractiveness and simplicity of design are incorporated to appeal to the students' physical and mental relaxation. As shown in the illustration, the tops of the desks are made of mar-proof plastics for ease of maintenance and cleaning, and the plastic model solar system over the instructor's desk has instructional value as well as decorative interest. It was reported that the plastic tile floor and the plastic molded desk are sturdier, wear longer, and will require less maintenance cost than most any other material available. The plastic molded chair backs and seats are designed to fit the contours of the body in order to give the growing child added support and comfort.

Leaving the school, one may study the field of transportation, and even here plastics are making their mark.

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4Ibid., p. 196.
Fig. 1.—Uses of Plastics in the Schoolroom
Aside from being used as interior trim for the last twelve years, plastic automobile bodies are now being manufactured for production. Allard, one of the large sports car manufacturers, now has begun the use of Celanese Marco "low pressure" resins laminated with glass cloth in the fabrication of automobile bodies. This type of new plastic body does not need heavy reinforcing ribs and framework, yet it may be produced in low-cost molds and cured at room temperatures. As for sturdiness and cost of repairs, damages can be mended easier, faster, and cheaper than on steel bodies, according to reports that have been made.  

When an individual studies the changes already made by the use of plastics in the manufacture of articles used in everyday living, he wonders about the things to come. Apparently, the plastics industry is now stable, and it looks as if nothing will prevent its continued gains in the future. William S. Dutton of the DuPont Company said that "the great revolution under way makes it appear that the advances of science and technology until now were at a snail's pace, compared to what they will be." This revolution in science will benefit the layman only to the extent of his ability to accept and use these advances.

No one can deny the tremendous use of plastics in the world today and the impression it is making on everyday living. The very existence of plastics lies in the fact that man was searching for something to replace a natural element,7 and from that point plastics have gone right on replacing numerous natural elements and materials. In some instances plastics have not only replaced certain scarce materials, but have surpassed some of the more plentiful raw materials because of their ease of fabrication and low cost when they are prefabricated into a finished article.

One cannot look about his own home without viewing an article or part of an article made of plastic. In the kitchen there may be plastic handles on the cooking ware, plastic parts on the appliances and electrical connections, plastic trim on the refrigerator, and a plastic top on the kitchen table; these are only a few of its uses. In the remainder of the home plastics are being used for such things as flooring, room partitions, upholstery, window sills and frames, wall paneling, and window screens.8

It is amazing to think that one might make quite a long list of the various uses of plastics today, and yet this is only the beginning. A prominent DuPont engineer had this to say about the development of plastics: "We'll advance a

century in the next ten years or so in the terms of prewar standards. It is quite possible that this gentleman may very well be correct when one sees that this industry grew from $35,000,000 in 1938 to a billion-dollar-a-year industry in 1948. Yes, plastics have definitely made their usefulness very evident in everyday living. The important point is that the extensive use of plastics has just begun, and the end is not in sight. Table 2 contains data and information concerning the growth and development of the plastics industry.

As shown in the foregoing statements, the growth of the plastics industry has been phenomenal, and it would be difficult, if not impossible, to predict the many uses that will be made of plastics in the near future. In 1947, William B. Stout, in speaking of the limitations of the plastics in the automobile field, stated as follows:

In words of one syllable, what the automobile industry needs from the plastics industry today is a plastic from which an automobile can be made.

Present day plastics are too expensive to fabricate, both from the standpoint of equipment and finesse of detail. Taking either first cost or production costs, no plastic today is suitable for an automobile frame or its wheels. . . .

If at any time a motorcar is to be made of plastics, it must be a totally new type of structure

9 Dutton, op. cit., p. 2.

10 Bernard, op. cit., p. 121.
### TABLE 2

PRODUCTION AND SALE OF SYNTHETIC RESINS, 1935-1952
(U. S. Tariff Commission)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Sales</th>
<th>Unit Value Per Lb.*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000 lb.</td>
<td>1000 lb.</td>
<td>1000 dollars</td>
</tr>
<tr>
<td>1952</td>
<td>2,333,924</td>
<td>2,043,880</td>
<td>726,924</td>
</tr>
<tr>
<td>1951</td>
<td>2,431,408</td>
<td>2,022,726</td>
<td>710,861</td>
</tr>
<tr>
<td>1950</td>
<td>2,155,518</td>
<td>1,875,604</td>
<td>570,917</td>
</tr>
<tr>
<td>1949</td>
<td>1,491,111</td>
<td>1,261,337</td>
<td>384,468</td>
</tr>
<tr>
<td>1948</td>
<td>1,480,876</td>
<td>1,239,531</td>
<td>369,476</td>
</tr>
<tr>
<td>1947</td>
<td>1,251,699</td>
<td>1,134,739</td>
<td>431,314</td>
</tr>
<tr>
<td>1946</td>
<td>1,025,118</td>
<td>965,893</td>
<td>339,222</td>
</tr>
<tr>
<td>1945</td>
<td>813,020</td>
<td>762,440</td>
<td>269,049</td>
</tr>
<tr>
<td>1944</td>
<td>782,352</td>
<td>697,328</td>
<td>211,342</td>
</tr>
<tr>
<td>1943</td>
<td>653,938</td>
<td>567,833</td>
<td>178,191</td>
</tr>
<tr>
<td>1942</td>
<td>439,999</td>
<td>381,522</td>
<td>152,551</td>
</tr>
<tr>
<td>1941</td>
<td>452,171</td>
<td>356,221</td>
<td>119,480</td>
</tr>
<tr>
<td>1940</td>
<td>276,814</td>
<td>201,100</td>
<td>59,368</td>
</tr>
<tr>
<td>1939</td>
<td>215,028</td>
<td>163,297</td>
<td>39,011</td>
</tr>
<tr>
<td>1938</td>
<td>130,359</td>
<td>101,822</td>
<td>22,872</td>
</tr>
<tr>
<td>1937</td>
<td>163,030</td>
<td>128,093</td>
<td>26,263</td>
</tr>
<tr>
<td>1936</td>
<td>132,913</td>
<td>100,880</td>
<td>20,648</td>
</tr>
<tr>
<td>1935</td>
<td>95,133</td>
<td>69,940</td>
<td>14,613</td>
</tr>
</tbody>
</table>

*These statistics are on a dry basis. Dry basis, for the purpose of this report, is defined as the total weight of the plastic or resin material, including resin, plasticizers, extenders, fillers, coloring agents, and stabilizers, but excluding the weight of solvents, water, and other liquid diluents.

designed throughout to take advantage of the new material.\(^\text{11}\)

Since 1947, plastics have been adapted to the automotive industry and are being used in the prefabrication of the entire body of the automobile.

In 1950, some of the engineers in the plastics industry believed that in the remote future the construction of an all-plastic house was possible, thus replacing wood in the construction of houses. It was reported that an ordinary house costing $6,500 when made of wood would cost approximately $100,000 when made of plastics.\(^\text{12}\)

In 1951, a private residence was built of plastics in Danville, California. This house was not necessarily an experimental model and contained 3,300 square feet of floor space; it was built at a cost reported to have been $16,445. This cost is comparable to the cost of similar houses built of other building materials and somewhat cheaper than some. It was reported that the plastic materials used have wonderful insulating qualities and are fireproof, mildew proof, termite proof, and warp proof. The construction of this house included plastic walls and roof; plastic materials were also used for the inside walls, cabinet work, counters, and.


cupboards, pipes for the heating and cooling units, and finally a plastic paint was used to finish the wood that was used. This construction was approved by the Federal Housing Administration; this approval lends some weight to the soundness of the idea that the future homes of America may be built of plastic materials.

With the increasing use of plastics and the tremendous growth of the industry, as previously shown in Table 2, there appears to be a need for consumer knowledge concerning these products. It is truly difficult to visualize the size of an industry even when one knows that there is a minimum of five thousand companies in the United States which make the raw materials, mold, or fabricate plastics. Plastics have invaded almost every phase of industry.

\[13\] Bernard, op. cit., p. 8.
CHAPTER III

AN EVALUATION OF FIVE TYPES OF PLASTICS
USED IN INDUSTRIAL ARTS PROGRAMS

A plastic has been defined as a material that can be softened and molded or pressed into a desired shape. Actually, plastics are divided into two main groups—thermosetting and thermoplastics. Nearly all of the plastics suitable for crafts work in industrial arts shops are of the thermoplastic type. Even though plastics have been of increasing commercial importance since 1920, it was not until the past few years that they have been available to anyone in quantities, except to manufacturers or to volume purchasers. Research has shown that a fairly comprehensive distributing system catering to the home craftsman and to industrial arts programs has been built up throughout the country within the past few years. A list of supply houses and plastic manufacturing firms was secured from MacRae's Blue Book\textsuperscript{1} and from the Modern Plastics Encyclopedia, 1953;\textsuperscript{2} letters were written to a number of the supply houses to ascertain the availability of plastics for use in industrial arts programs.

\textsuperscript{1}MacRae's Blue Book, Vol. LIX, 1952, pp. 2482-2501.
\textsuperscript{2}Modern Plastics Encyclopedia, 1953.
Development of Criteria for Use in Evaluating Plastics

The study revealed that there were many different types of plastics and that many books have been written on plastics and their uses, but research failed to reveal any suitable criteria that could be used by the average industrial arts teacher to guide him in the selection of various plastics in regard to their suitability and use by students in constructing projects. Groneman, Cherry, Lockrey, DeWick, Cooper, Mansberger, and Pepper have used the term "plastics" rather loosely in the books they have designed and written on the subject for use as texts in the public schools. In order to conduct this study and to evaluate the various plastics that are available to industrial arts shops, it was necessary to develop some type of standards or criteria to use in evaluating the various plastics in order to determine their use or probable use in industrial arts programs.

No doubt there are many types of plastics that possess many characteristics which would make them desirable for use in an industrial arts program, but because of the demand of industry for these plastics for industrial purposes, they are not readily available to the average industrial arts teacher. If the material is not readily available to those who wish to use it, it would have little actual value in this respect as a material for industrial arts programs. Therefore, it seems logical that one criterion of measure is that each of
the various plastics presented in this study should meet to a satisfactory degree the following: Is the plastic available to schools for use in industrial arts programs?

Research has shown that it actually costs a student on an average of $125.00 per year to attend the so-called public schools in the United States, and industrial arts has been referred to at times as one of the luxury courses or special courses often found in the curriculum, meaning that it is expensive to both the school and the student when it is compared with courses in other subject matter areas. This cost of industrial arts courses to the student is due to the materials used and their cost. One factor considered by industrial arts teachers when they are planning courses and selecting materials to be used by students enrolled in industrial arts courses is the cost. A material may possess many desirable traits, but if the price of the material is excessive, the students cannot afford to use the material. One criterion of measure that should be considered in the selection of a certain plastic for use in industrial arts programs could be as follows: Is the price of the plastic comparable to that of other materials used in the program, or is the cost of the projects made of plastics by the students comparable to the cost of projects made of other materials?

Another factor to be considered in the selection of a plastic for use in the construction of projects in an industrial arts program is whether the plastic can be worked with the common hand tools found in the average industrial arts shop. Many of the industrial arts shops in the public schools are equipped only with hand tools, and unless the plastic can be worked with common hand tools, it would actually have little value as a material. Research has shown that some of the plastics used in industry are very tough and durable and can be worked only with high speed saws, routers, and drills. Some are soft and cannot be worked with high speed machinery, because friction destroys the plastic itself. In order to be suitable, generally speaking, plastics suitable for use in industrial arts programs should be of such a nature that they can be worked with hand tools.

In the greater number of instances, the use of plastics in the construction of projects will involve fastening many pieces together. Since many of the plastics are transparent, and much of the stock often used is one-eighth inch or less in thickness, it is not possible to use screws to fasten the pieces together. As a result, the plastics selected for use in industrial shops must be of such a nature that they will bond readily through the use of a commercial cement that is inexpensive and safe for the student to use. Therefore, one criterion of measure that a plastic should meet in order
to be classified as suitable for use in an industrial arts program would be as follows: Does the plastic cement readily through the use of commercial cements that are inexpensive and safe?

Many of the projects commonly made of plastics by students will require stock of various thicknesses and shapes, such as flat sheets, squares, cylinders, and hollow tubes. Therefore, in order for a plastic to be considered practical for use in the average industrial arts program, it should be available in various forms and shapes.

When plastics were first discovered and introduced as an industrial material, the majority of the various types available were clear or transparent. Many of the projects often-times made by students in an industrial arts program may be made of plastics that are clear or transparent, but often-times the student finds a need for plastics of different colors in order to construct a certain project. A factor that should be considered in the selection of plastics would be as follows: Is the plastic obtainable and available to industrial arts programs in several different colors?

Occasionally, a project made of plastic will involve surfaces that are curved or irregular in shape and cannot be secured from using regular stock in cylindrical form. These curved surfaces and irregular shapes must be formed by various means. A factor to be considered in the selection of a plastic for use in an industrial arts program is whether the
plastic may be formed to desired shapes in the school shop without the use of expensive equipment.

In the prefabrication of projects from plastics, the edges and working surfaces of the stock will become marred and will show tool marks of the various tools used in the drilling, cutting, and filing operations necessary to reduce the stock to the desired size. In order for the project to have a finished look and to be acceptable, these tool marks and marred places must be removed. Therefore, it is necessary for plastics used in an industrial arts program to be buffed or polished easily to an acceptable finish with the use of common and inexpensive buffing wheels and equipment.

Research in this study revealed that, generally speaking, most of the various plastics will burn and that cellulose nitrate is considered to be highly inflammable. In all probability there are other members of the plastic family that are inflammable to a certain extent and as a result might be unsafe for use by students in an industrial arts program. One factor that should be considered in the selection of plastics for use in the construction of projects in an industrial arts program would be as follows: Is the plastic safe for high school students to use with respect to whether it is highly inflammable?

No doubt continued research and study would reveal additional factors that should be considered and used to study and evaluate the various plastics available for use in the
construction of projects in industrial arts programs. It is believed, however, that the aforementioned factors can be used as criteria and can be applied to the various plastics presented in this study; they will reveal information concerning the suitability of each of the various plastics and its use in industrial arts programs.

These aforementioned factors are restated for use in this study as follows:

1. Is the plastic available in quantity to schools for use in industrial arts programs?

2. Is the cost of the plastic comparable to that of other materials used in industrial arts programs?

3. Can the plastic be worked with the common hand tools found in the average industrial arts shop?

4. Can the plastic be worked with the common power tools found in the average industrial arts shop?

5. Can the plastic be joined through the use of an inexpensive and safe cement?

6. Can the plastic be obtained in a variety of shapes, such as squares, cylinders, hollow tubes, and sheets?

7. Can the plastic be finished without the aid of expensive buffing wheels and equipment?

8. Can the plastic be obtained in a variety of colors?

9. Is the plastic safe for students to use with respect to not being highly inflammable?
10. Can the plastic be shaped to the desired form without the use of expensive equipment?
The foregoing factors will be considered as criteria and will be used and applied to each of the plastics presented.

A check list, in the form of a table, was developed and used in evaluating each plastic presented. It was necessary to select three terms to describe the extent to which the various plastics met each criterion of measure. The terms used were "extensively," "moderately," and "slightly." It was deemed necessary, however, to add a fourth term to be used in case any one of the plastics presented failed to meet the criteria in any way.

Evaluation of Plastics for Use in the Industrial Arts Shop

The following evaluation covers four types of plastics which may be purchased in one or more of the many plastics supply houses. These four types of plastics--acrylic, cellulose, vinyl, and polystyrene--were subjected to the criteria already mentioned and should be judged accordingly.

Acrylics.--Acrylic plastics, one of the more common groups of plastics, are a thermoplastic material. This group of plastics possesses a crystal clarity; they are important commercially because of their remarkable optical qualities.4

4J. H. Dubois, Plastics, p. 85.
as well as the ability to transmit light.\(^5\) Some of the typical uses of this group are as follows: lamp bases, airplane canopies, windows, camera viewing lenses, dentures, surgical instruments, scale models, outdoor signs, and counter displays.\(^6\) The above uses represent only a small portion of the present day uses of the acrylic group of plastics.

Otto Rohm did the first research with the acrylic group of plastics in 1901; it was not until 1931, however, that acrylic plastics were first manufactured in the United States by Rohm and Haas Company, Washington Square, Philadelphia, Pennsylvania. This type of plastic was first used for coatings and for bonding safety glass. In 1936, the Rohm and Haas Company began producing a methyl methacrylate sheet material which was and is still called Plexiglas. Shortly after this, in 1937, E. I. duPont de Nemours and Company, Wilmington, Delaware, produced a similar sheet plastic which was called Lucite.\(^7\) Plexiglas and Lucite are almost exactly alike in both appearance and chemical content and up to the present time are the only two sheet plastics in this group.

Plexiglas and Lucite have been used to a greater degree in the field of industrial arts than have some of the other plastics. When one speaks of working with plastics in the

\(^5\)A. J. Lockrey, *Plastics*, p. 3.


\(^7\) Dubois, *op. cit.*, p. 85.
school shop, it is usually believed that Plexiglas or Lucite is the type of plastic being used. This popularity should speak for itself as to the practical use of these materials in present school shop situations, but in all fairness to the other types of plastics available on the present market, it is only right to evaluate these two materials the same as the others.

As to their availability, Plexiglas and Lucite may be secured from many plastic supply houses throughout the Nation in the form of flat sheets, rods, and tubes, as well as in scrap bundles. The various supply houses usually have plenty of this material on hand, and a teacher should encounter little difficulty in obtaining the quantity and shapes of pieces needed.

The cost of Plexiglas and Lucite can be kept reasonably low by purchasing Plexiglas and Lucite in quantities labeled as "mixed scrap," which may run as low as $1.05 per pound with a minimum order of ten pounds. The flat sheet stock may be purchased for $1.20 per square foot for stock one-sixteenth inch in thickness, with the price rising proportionately for thicker material. The industrial arts

See Appendix A for a list of supply houses.


teacher should secure several catalogues and check several supply houses as to cost. The price of Plexiglas and Lucite listed as "scrap" usually differs greatly with the individual companies, whereas the price of standard size flat sheets, rods, and tubes is reasonably stable in this respect.

Plexiglas and Lucite may be worked with many of the various hand tools found in the average industrial arts shop, as indicated in Table 3. Normal cuts may be made with the common hand saw, as well as with the coping saw. It is also considered good practice to use a hand drill for drilling holes and the flat mill file for shaping and smoothing acrylic pieces. There are also many other hand tools which may be adapted to the working of these two plastics if the instructor takes the time to avail himself of their characteristics.

Power tools lend themselves very well to use with acrylics. The Rohm and Haas Company recommends the use of the common power tools found in either the industrial arts wood or metal shops. They recommend in Bulletin Number 2a on Design, Fabrication, and Molding Data that it is good practice to use the circular saw, band saw, and jig saw for cutting Plexiglas. This bulletin does state, however, that for extensive

11Cadillac Plastic Company, How to Work with Plexiglas, p. 3.
TABLE 3
INFORMATION CONCERNING THE SUITABILITY OF ACRYLIC PLASTICS AS A MATERIAL FOR USE IN AN INDUSTRIAL ARTS PROGRAM

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Extensively</th>
<th>Moderately</th>
<th>Slightly</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is the plastic available in quantity to schools for use in industrial arts programs?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Is the cost of the plastic comparable to that of other materials used in industrial arts programs?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Can the plastic be worked with the common hand tools found in the average industrial arts shop?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Can the plastic be worked with the common power tools found in the average industrial arts shop?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Can the plastic be joined through the use of an inexpensive and safe cement?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Can the plastic be obtained in a variety of shapes, such as squares, cylinders, hollow tubes, and sheets?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Can the plastic be finished without the aid of expensive buffing wheels and equipment?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Can the plastic be obtained in a variety of colors?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Is the plastic safe for students to use with respect to not being highly inflammable?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Can the plastic be shaped to the desired form without the use of expensive equipment?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
use of plastics with these machines a separate blade should be kept for each machine for this purpose. Having used Plexiglas and Lucite for both class projects and experimental purposes in the Denton High School Shop, Denton, Texas, the author found that the use of such machines as the belt sander, drill press, and router with acrylic plastics is very satisfactory.

Cementing acrylic plastic is both simple and inexpensive. Numerous prepared cements are on the market, such as Cement I-B, Cement II, and others; for simple bonding of acrylcs, however, one of the cheapest cements at the present time is ethylene dichloride. This chemical is recommended by Rohm and Haas Company in a bulletin entitled Bulletin Number 7b on Cementing Acrylic Plastics. This particular cement sells for less than $3.00 per gallon on the retail market at the present time, according to information secured from the Worth Chemical Company of Fort Worth, Texas.

Both Plexiglas and Lucite are available in the form of flat sheets, rods, squares, and hollow tubes. These particular forms lend themselves well to the construction of projects in industrial arts programs, as will be noted in the following chapter.

13Rohm and Haas Company, Bulletin Number 7b on Cementing Acrylic Plastics, p. 7.

Because of the relatively soft surface found on the acrylic plastics, finishing is not a difficult job. The removing of scratches and mill marks may be accomplished by using a fine-cut flat mill file, followed by sanding with a coarse grit (240A) of wet-or-dry paper. A fine grit (400A-600A) of wet-or-dry paper should be used after the coarser paper, and the final polish is accomplished by the use of a flannel or cotton buffing wheel. Any soft buffing wheel attached to an electrical drill, drill press, or any other type electric motor will produce a nice finish.15

Another good feature of acrylic plastics for use in the industrial arts program is the wide color range and surface texture in which they are available. Through teaching experience, one may well realize the importance that the application of colors to projects has in arousing the interest of students. Plexiglas and Lucite are manufactured in a wide range of transparent, translucent, and opaque colors, as well as in corrugated and patterned surfaces.16 These features should help to enlarge the field of possible projects and student interest.

Acrylic plastics are also safe for students to use. They have a slow burning rate and will not flash ignite.17

17Ibid.
This fact is important to the fire insurance companies, as well as to the safety of the student and instructor.

Since Plexiglas and Lucite are thermoplastic, they become soft and pliable when heated and can be formed to almost any shape. For heat-forming a small electric oven that will produce temperature of 250 degrees Fahrenheit may be used. The actual temperature for forming will vary slightly with the thickness of the material to be formed. For instance, a thin sheet, one-sixteenth of an inch in thickness, would be heated to a higher temperature for forming than would a one-fourth inch sheet, because the thinner sheet cools faster, and one does not have sufficient time to form it before it cools. The forming blocks or jigs may be made in the industrial arts shop to fit any specific project, so the forming equipment needed is actually relatively inexpensive.

In summarizing the use of acrylic plastics in the industrial arts shop, it may be said that it is extremely versatile and well adapted to most any use in the field of plastics. Acrylic plastics are readily available, relatively cheap, and as shown in Table 3, this group of plastics meet all of the criteria to a high degree. Plexiglas and Lucite should definitely be considered as a suitable material for use in the industrial arts program.

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Cellulose Plastics

There are actually four cellulose plastics, and they are all thermoplastic. Cellulose nitrate was one of the first plastics discovered (1868) and might be considered as the beginning of the plastics industry of today. The second cellulose compound was not discovered until 1927, and it was known as cellulose acetate. This discovery was soon followed by the development of cellulose acetate butyrate in 1932 and ethyl cellulose in 1935. These four discoveries formed the nucleus of a group of plastics that reached a production volume of 96,300,000 pounds in 1952. In order to study this group of plastics it was necessary to divide them into the four basic types, starting with the first discovered, cellulose nitrate.

Cellulose Nitrate.—The production of cellulose nitrate was started in this country in 1868 by John Wesley Hyatt. This plastic was produced under the trade name of Celluloid, and it still maintains this name today. Since the initial discovery of cellulose nitrate, there has been a great number of variations of this plastic appearing under the trade names of Amerith, Nitron, Nixonoid, and Pyralin.

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to name only a few. Aside from having different trade names and being manufactured by different companies, the cellulose nitrate plastics have essentially the same characteristics and can, for all practical purposes, be classified together. When cellulose nitrate plastics are evaluated with the criteria, any variation in characteristics of particular nitrate plastics will be noted in the summary following the evaluation.

At the present time cellulose nitrate plastics are not found in many of the general plastics supply houses. It is highly possible that if a person were interested enough in a particular nitrate, he might inquire of the company producing it for recommendations as to how to obtain it. After checking a number of the national and local catalogues of companies selling plastics, it was found that cellulose nitrate plastics are not readily available to industrial arts teachers and home craftsmen.

With reference to the cost of cellulose nitrate plastics, there was not enough information available to determine whether the cost of this group of plastics would be prohibitive for use in industrial arts classes.

One point in favor of the use of nitrate plastics as a material in industrial arts programs is their ease of working. Many of the common hand tools found in the

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industrial arts shop may be used in the fabrication of cellulose nitrate plastic projects. This quality is definitely an asset, as it cuts down on the purchase of additional equipment by the school.

Cellulose nitrate plastics are also easily machined, as indicated in Table 4. Almost any type of power tool may be used in the fabrication of projects from these plastics. It is recommended that a generous stream of water be used as a cooling agent, however, because all nitrate plastics are combustible.23

Almost any organic solvent is a satisfactory bonding agent in cementing nitrate plastics.24 The organic solvents are more common on the commercial market than are some cements, and they should be easily obtainable. Acetone is the most common of these solvents and is listed by many supply houses; however, it is not always the cheapest.

Nitrate plastics are produced chiefly in the form of flat sheets, rods, films, and tubes.25 This factor, as has been mentioned before, is especially desirable because of the ease of project fabrication made possible with the above forms.

23Simonds and Ellis, op. cit., p. 175.
24Nixon Nitrate Works, op. cit., p. 4.
### TABLE 4

INFORMATION CONCERNING THE SUITABILITY OF CELLULOSE NITRATE PLASTIC AS A MATERIAL FOR USE IN AN INDUSTRIAL ARTS PROGRAM

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Degree to Which the Plastic Meets Each Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extensively</td>
</tr>
<tr>
<td>1. Is the plastic available in quantity to schools for use in industrial arts programs?</td>
<td>X</td>
</tr>
<tr>
<td>2. Is the cost of the plastic comparable to that of other materials used in industrial arts programs?</td>
<td></td>
</tr>
<tr>
<td>3. Can the plastic be worked with the common hand tools found in the average industrial arts shop?</td>
<td>X</td>
</tr>
<tr>
<td>4. Can the plastic be worked with the common power tools found in the average industrial arts shop?</td>
<td>X</td>
</tr>
<tr>
<td>5. Can the plastic be joined through the use of an inexpensive and safe cement?</td>
<td>X</td>
</tr>
<tr>
<td>6. Can the plastic be obtained in a variety of shapes, such as squares, cylinders, hollow tubes, and sheets?</td>
<td>X</td>
</tr>
<tr>
<td>7. Can the plastic be finished without the aid of expensive buffing wheels and equipment?</td>
<td>X</td>
</tr>
<tr>
<td>8. Can the plastic be obtained in a variety of colors?</td>
<td>X</td>
</tr>
<tr>
<td>9. Is the plastic safe for students to use with respect to not being highly inflammable?</td>
<td>X</td>
</tr>
<tr>
<td>10. Can the plastic be shaped to the desired form without the use of expensive equipment?</td>
<td>X</td>
</tr>
</tbody>
</table>
The finishing of nitrate plastics is much the same as that of the acrylic plastics. The surface texture is fairly soft and can be easily sanded and buffed to a high lustre. The Nixon Nitrate Company, Nixon, New Jersey, suggests the immersing of the article in butyl acetate or some other solvent for a few minutes, followed by air drying. This process will also clean the surface.

The color range of nitrate plastics is almost limitless. The colors range from clear transparents, color transparents, and translucents to deep opaques in all colors of the spectrum. They are also produced to imitate the grains of wood, marble, mottles, burnished metals, and pearls. This wide color range should be of value as a means of stimulating student interest in plastics.

A factor which should be mentioned concerning the use of cellulose nitrate products in the industrial arts shop is its flammability. All nitrate plastic stock, unless it has been especially treated, is highly combustible; therefore, certain precautions should be taken when it is used. Scrap and shavings should be kept clear of the working areas, and it is recommended that a cooler be used in machine

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28 Groneman, op. cit., p. 17.
operations. Under ordinary working conditions it is not probable that a fire would start; however, should the nitrate stock come in contact with an open flame, the situation created should be termed as dangerous. With this in mind, it is doubtful that cellulose nitrate should be used in the industrial arts shops, and if used at all, safety precautions should be observed very closely.

Cellulose nitrate stock is a thermoplastic and can be formed easily. The softening point is about 190 degrees Fahrenheit; this permits the use of a small hot plate or electric oven as a heating device. Sheet stock can be easily shaped by drawing, swaging, die-forming, blowing, and other similar operations. Die-forming would probably be the most common method used in a high school shop. This type of forming allows the students to make their own dies, thereby broadening the scope of their learning experiences and activities.

In summarizing the use of cellulose nitrate plastic as a material in the industrial arts shop, it should be noted that this type of plastic has many limitations when evaluated by the criteria shown in Table 4. This type of plastic is not readily available through the normal supply

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29 Nixon Nitrate Company, op. cit., p. 4.
30 Dubois, op. cit., p. 70.
channels and might also be scored low with respect to being used safely by students. Both of these factors should be considered and might render the cellulose nitrate plastics as unsuitable for use in industrial arts shops. Certainly, with so many other plastics available on the market today, an industrial arts teacher should consider all of the information shown in Table 4 thoroughly before deciding for or against the use of cellulose nitrate plastic as a material in the industrial arts shop.

**Cellulose Acetate.**—Cellulose acetate was first used in 1912 for photographic film, but it was not introduced to the general plastics industry until 1927. It was at this time that it was offered in the form of flat sheets, rods, and tubes. Molding materials made from cellulose acetate were first available in 1929, and by 1934, this type of plastic was a contender for first place in the plastics industry.\(^\text{32}\)

Today, after twenty years, it is still one of the leading plastic materials on the commercial market.\(^\text{33}\) Some of the typical articles made of this type of plastic are combs, novelty jewelry, tooth brushes, toys, glazing, automobile hardware, and transparent containers.\(^\text{34}\)

As is the case with so many types of plastics, there are a number of trade names associated with cellulose acetate.

\(^{32}\)Dubois, *op. cit.*, p. 72.


\(^{34}\)ibid., p. 25.
Many different firms produce it, and some of the trade names associated with this plastic are Ampacet, Gering C/A, Herculcel A, Lumarith, Nixon C/A, Plasticel, Tenite I, and Vuepak. The above-mentioned plastics have similar characteristics and are all actually cellulose acetate and will be evaluated according to the criteria set up in Table 5.

Cellulose acetate plastics are readily available from commercial supply houses. Although this group of plastics may not be as well known and handled by as many supply houses as are the acrylic plastics, they are definitely on the open market. There are a number of catalogues produced by the supply houses listed in Appendix "A" which list cellulose acetate according to the sizes in which it is manufactured and the cost.

Although cellulose acetate is readily available through normal commercial supply houses, it was noted that the thickest sheet stock available is one-sixteenth of an inch. The price of sheet stock is based on the standard sheet, which is twenty by fifty inches in size; the cost is $6.92 per sheet. When the price is figured on the basis of cost per square foot, this plastic is actually a little cheaper than the same thickness of Plexiglas and Lucite, which sell for approximately $1.25 per square foot.

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37 Ibid., p. 1.
TABLE 5
INFORMATION CONCERNING THE SUITABILITY OF CELLULOSE ACETATE PLASTIC AS A MATERIAL FOR USE IN AN INDUSTRIAL ARTS PROGRAM

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Degree to Which the Plastic Meets Each Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extensively</td>
</tr>
<tr>
<td>1. Is the plastic available in quantity to schools for use in industrial arts programs?</td>
<td>X</td>
</tr>
<tr>
<td>2. Is the cost of the plastic comparable to that of other materials used in industrial arts programs?</td>
<td>X</td>
</tr>
<tr>
<td>3. Can the plastic be worked with the common hand tools found in the average industrial arts shop?</td>
<td>X</td>
</tr>
<tr>
<td>4. Can the plastic be worked with the common power tools found in the average industrial arts shop?</td>
<td>X</td>
</tr>
<tr>
<td>5. Can the plastic be joined through the use of an inexpensive and safe cement?</td>
<td>X</td>
</tr>
<tr>
<td>6. Can the plastic be obtained in a variety of shapes, such as squares, cylinders, hollow tubes, and sheets?</td>
<td>X</td>
</tr>
<tr>
<td>7. Can the plastic be finished without the aid of expensive buffing wheels and equipment?</td>
<td>X</td>
</tr>
<tr>
<td>8. Can the plastic be obtained in a variety of colors?</td>
<td>X</td>
</tr>
<tr>
<td>9. Is the plastic safe for students to use with respect to not being highly inflammable?</td>
<td>X</td>
</tr>
<tr>
<td>10. Can the plastic be shaped to the desired form without the use of expensive equipment?</td>
<td>X</td>
</tr>
</tbody>
</table>
Cellulose acetate appears to be ideal for handwork. It is very soft in texture and lends itself well to the hand tools found in the average industrial arts shop. It is also soft enough to be used at home and worked by the "scissors-and-hot-water" method. This may prove especially helpful to the student because of the possibility of using this material as a means of pursuing an inexpensive hobby.

The fabrication of projects from cellulose acetate plastics may be accomplished through the use of the common power tools found in the average industrial arts shop. It should be noted, however, that this type of plastic will tend to gum the machine unless it is properly used. Some authors of books, bulletins, and pamphlets treating plastics are of the opinion that the amateur will experience some difficulty in the use of machines with this material. The industrial arts instructor should check this point before purchasing a quantity of this type of plastic for use by his students.

The acetate plastics are very easily cemented. Again acetone seems to be the most common bonding agent used with this type of plastic; yet it may be generally conceded that just about any organic solvent may be used.

\[^38\text{Lockrey, op. cit., p. 4.}\quad ^39\text{Ibid.}\]
\[^40\text{Nixon Nitrate Company, op. cit., p. 5.}\]
\[^41\text{Lockrey, op. cit., p. 4.}\]
\[^42\text{Simonds and Ellis, op. cit., p. 168.}\]
Cellulose acetate plastics are readily available in the form of flat sheets, rods, and tubes, and as is the case with many other types of plastics, this type is also available in other forms, such as pellets and molding powders. The average industrial arts teacher is mainly interested in the product for student use; therefore, the material in the form of sheets, rods, and tubes will be of the most importance.

The finishing of cellulose acetate plastics is a rather simple undertaking. These plastics are similar to the acrylic plastics in texture and may be buffed and polished in much the same manner. Care should always be taken not to overheat the plastic by holding it stationary on the buffing wheel too long. Overheating tends to distort the finish and may ruin the appearance of a project.

The color possibilities are virtually limitless with the acetate plastics. Like the other cellulose compounds, they may be secured in all the colors of the spectrum. This includes the transparents, translucents, opaques, and all of the other configurations mentioned in the treatment of cellulose nitrate plastics.

Cellulose acetate plastics, unlike the cellulose nitrate plastics, are safe to use. Cellulose acetate plastics are

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44 Nixon Nitrate Company, op. cit., p. 5.
45 DeWick and Cooper, op. cit., p. 5.
usually termed as slow burning, and one does not have to fear the possibility of flash igniting.\footnote{46}

The forming qualities of the cellulose acetate plastics appear to be very good. Acetate plastics will soften at 160 degrees Fahrenheit and may be readily formed by the use of simple dies. As with most plastics, however, cellulose acetate plastics may be overheated and ruined. Therefore, an oven thermometer should be used to determine the correct temperature.\footnote{47}

The cellulose acetate plastics appear to be of a good over-all quality, and although they do not conform wholly to the criteria, it is believed they could be used satisfactorily in the industrial arts shop. The weak tensile strength and dimensional stability of acetate plastics are two items which should be noted.\footnote{48} These points should be considered before cellulose acetate plastics are used for certain projects.

\textbf{Cellulose Acetate Butyrate.}--Cellulose acetate butyrate plastics are similar to the cellulose acetate plastics that have been presented. There is so little difference between the two types that it is not believed necessary to evaluate cellulose acetate butyrate plastics for the purpose

\footnote{46}Dubois, \textit{op. cit.}, p. 76. \footnote{47}Ibid., p. 77. \footnote{48}Ibid., p. 4.
of this study. There are a few items, however, which will be mentioned. For one thing cellulose acetate butyrate plastics are lighter in weight than the cellulose acetate plastics; they also have better dimensional stability, less distortion under varying degrees of heat and humidity, and a lower moisture absorption.49 It might be said that cellulose acetate butyrate plastics were developed to alleviate some of the shortcomings of cellulose acetate.

At the present time Tenite II and Nixon C/AB are about the only two trade names on the market identified with the acetate butyrate plastics. These plastics, being an improvement over the cellulose acetate plastics, are enjoying what one might term as a shortage on the market at the present time. Production is not keeping pace with demand; therefore, they are not available to the general consumer.50

Ethylcellulose.--The last of the cellulose plastics found to be available on the market at the present time is ethylcellulose. This type of cellulose plastic was introduced to the public in 1937,51 and since that time its use has increased some, but it is not yet widely used. The best market for this material appears to be in the form of protective coatings, adhesives, low-temperature insulators, and

for thin transparent sheeting. There does appear to be some indication that this plastic is being made in the form of flat sheets, rods, and tubes, but as yet very little, if any, has appeared on the open market.

Dow Chemical Company, Midland, Michigan, and the Hercules Powder Company, Wilmington, Delaware, which are both large producers of this type of plastic, were contacted, but not enough information or samples of ethylcellulose were obtained to evaluate this material as to its suitability and probable use in industrial arts programs. All of the information available at the present time indicates that it is a thermoplastic, can be machined, is manufactured in a wide variety of colors, and is slow burning. It is highly possible that this plastic will become available to the general public sometime in the near future, in quantity, and that it can be used in the industrial arts program.

Vinylite Plastics

Vinyl plastics are relatively new on the open market; in fact, the first vinyls were discovered in 1936. This type

52Dubois, op. cit., p. 82.
54Ibid., p. 14.
55Ibid., p. 15.
56Simonds and Ellis, op. cit., p. 49.
57Ibid.
of plastic has steadily grown in popularity and in 1952, enjoyed a production year totaling four hundred million pounds. At the present time there are seven major types of this plastic on the market, and they are produced in both the flexible and rigid forms.

The selection of the different types of plastics for this study was governed in part by their possible uses in the high school shop; therefore, the actual evaluation of the vinyl plastics was limited to Vinylite, which is the only vinyl plastic available to the general public at the present time. Vinylite is produced by the Bakelite Corporation, 30 East 42nd Street, New York 17, New York, and was chosen principally because it is available in rigid sheet materials. Experience has shown that this form of plastic lends itself best to school shop situations and projects.

Vinylite is a thermoplastic material and is produced from vinyl chloride-acetate resins. It is an odorless, tasteless, and non-toxic material, and therefore is especially useful for food containers. Some other uses include house numbers, refrigerator dials, toys, dolls' heads, and drawing instruments. Vinylite has good dimensional

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59 Ibid.
60 Bakelite Corporation, Vinylite-Resins and Plastics, p. 17.
61 Ibid., p. 18.
stability and will not warp under normal pressure. It is produced in a standard rigid sheet size of twenty inches by fifty inches and in thickness from one-hundredth of an inch to one-eighth of an inch.\textsuperscript{62}

In order to determine the suitability of Vinlylite as a possible material for the construction of projects in industrial arts shops, this plastic was evaluated by the criteria shown in Table 6.

Vinlylite may be purchased from a number of supply houses throughout the United States and in Texas from the A. & A. Plastics Supply Company, Dallas, Texas.\textsuperscript{63} Although it may not be as well known as some of the acrylic plastics and possibly is not as well advertised, Vinlylite is readily available through normal supply channels.

The cost of Vinlylite appears to be comparable to Plexiglas. The average price at this time is $1.60 per square foot for stock one-eighth of an inch in thickness,\textsuperscript{64} as compared to $1.56 per square foot for one-eighth inch Plexiglas.\textsuperscript{65}

Vinylite is a true thermoplastic and may be worked by common methods used in fabricating plastic sheets.\textsuperscript{66} This

\textsuperscript{62}\textit{Ibid.}, p. 17.
\textsuperscript{63}See Appendix A for a list of supply houses.
\textsuperscript{65}\textit{Ibid.}, p. 1.
\textsuperscript{66}Bakelite Corporation, \textit{op. cit.}, p. 17.
TABLE 6

INFORMATION CONCERNING THE SUITABILITY OF VINYLITE PLASTIC AS A MATERIAL FOR USE IN AN INDUSTRIAL ARTS PROGRAM

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Degree to Which the Plastic Meets Each Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extensively</td>
</tr>
<tr>
<td>1. Is the plastic available in quantity to schools for use in industrial arts programs?</td>
<td>X</td>
</tr>
<tr>
<td>2. Is the cost of the plastic comparable to that of other materials used in industrial arts programs?</td>
<td>X</td>
</tr>
<tr>
<td>3. Can the plastic be worked with the common hand tools found in the average industrial arts shop?</td>
<td>X</td>
</tr>
<tr>
<td>4. Can the plastic be worked with the common power tools found in the average industrial arts shop?</td>
<td>X</td>
</tr>
<tr>
<td>5. Can the plastic be joined through the use of an inexpensive and safe cement?</td>
<td>X</td>
</tr>
<tr>
<td>6. Can the plastic be obtained in a variety of shapes, such as squares, cylinders, hollow tubes, and sheets?</td>
<td>X</td>
</tr>
<tr>
<td>7. Can the plastic be finished without the aid of expensive buffing wheels and equipment?</td>
<td>X</td>
</tr>
<tr>
<td>8. Can the plastic be obtained in a variety of colors?</td>
<td>X</td>
</tr>
<tr>
<td>9. Is the plastic safe for students to use with respect to not being highly inflammable?</td>
<td>X</td>
</tr>
<tr>
<td>10. Can the plastic be shaped to the desired form without the use of expensive equipment?</td>
<td>X</td>
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</table>
permits the use of the common hand tools found in an average industrial arts shop.

Vinylite is also readily machined. It is considered very satisfactory for use with machines such as the power saw, jointer, and drill. All of the above machines are in the average industrial arts shop and are used by the average student.

Because of the nature of projects constructed in the average high school shop, it is highly desirable that the plastic used be readily cemented. Vinylite meets this requirement. It can be bonded easily by both heat and solvent sealing. The common solvents include ketones, certain esters, and chlorinated hydrocarbons, which may be purchased through many of the dealers who sell Vinylite.

Vinylite may be purchased in a wide range of forms. It may be purchased in the form of molding powders, flexible sheets, rigid sheets, rods, and tubes. This permits the use of this product in many projects; however, the plastic in the form of rigid sheets, rods, and tubes would probably be of the most use in the school.

The finishing of Vinylite may be accomplished much in the same manner as the other thermoplastics. The use of the

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67Ibid.
68Ibid.
machine and the common hand buffer with a mild abrasive is very effective.\textsuperscript{70} Also, care must be taken not to overheat the material, as a disfiguration will result.

The color range of Vinylite is almost limitless.\textsuperscript{71} The common plastics of today are usually colorful, and this type of plastic is no exception. With the growing use of plastics, the color qualities appear to be becoming more important, and certainly this quality should be important in selecting plastics for use in industrial arts classes.

The safety factor is also something which should be considered in a high school shop. Because of the slow-burning characteristic of Vinylite,\textsuperscript{72} as well as its non-toxic and odorless qualities, it should be noted that Vinylite is safe for high school students to use.

Vinylite, like the other thermoplastic materials already mentioned, is easily formed. Its softening point is 130 degrees Fahrenheit,\textsuperscript{73} a heat which can be obtained easily by the use of a simple hot plate or homemade oven. The use of inexpensive, homemade equipment is always an advantage with respect to the cost and upkeep of equipment for a school course and should be utilized wherever possible.

\textsuperscript{70}Nixon Nitrate Company, \textit{op. cit.}, p. 6.
\textsuperscript{71}Bakelite Corporation, \textit{op. cit.}, p. 16.
\textsuperscript{72}Plastics, \textit{The Story of an Industry}, p. 24.
\textsuperscript{73}\textit{Ibid.}
The use of vinyl plastics and particularly Vinylite in the school shop should be considered. The main factor which may be termed a disadvantage is its availability, particularly in the form of rods and tubes. Although it is on the market, this type of plastic may be more difficult to find than the acrylics, especially in outlying areas. This, however, will be for the instructor to investigate as to his particular locality.

Polystyrene Plastics

This type of plastic was originally produced in England in 1839.\(^{74}\) It was also used extensively in Germany for many years\(^ {75}\) but was not used commercially in the United States until about 1937.\(^ {76}\) The main reason for the late start of styrene production in the United States appears to have been due to its relatively high cost.\(^ {77}\) Polystyrene is a thermoplastic and has become rather widely used in the United States in the last decade. Its production totaled three hundred four million pounds in 1952,\(^ {78}\) and from all indications it will continue to grow in usage. Some of the items

\(^ {74}\)Dubois, op. cit., p. 106.

\(^ {75}\)Dale Mansperger and Carson W. Pepper, Plastics, Problems and Processes, p. 24.

\(^ {76}\)Dubois, op. cit., p. 106.

\(^ {77}\)Mansperger and Pepper, op. cit., p. 24.

\(^ {78}\)Plastics, The Story of an Industry, p. 22.
produced from this type of plastic are refrigerator food containers, toys, battery cases, wall tile, and portable radio housings.\(^79\)

In this study very little written information was found describing this type of plastic and its uses. It was therefore necessary to rely on actual testing in the industrial arts shop to determine its use or probable use in the industrial arts program as a material in the construction of projects.

Polystyrene is listed in some of the catalogues which are published by the various companies listed in Appendix A; however, it is not as plentiful as some of the other plastics, such as Plexiglas and Lucite. Polystyrene might also be difficult to find in the form of "scrap" because of its relatively high cost.

This type of plastic is high in cost in comparison to other plastics on the market, as shown in Table 7. The A. & A. Plastics Supply Company, Dallas, Texas, is currently selling polystyrene clear sheet stock, one-sixteenth inch in thickness, for $1.77 per square foot. This same company is currently selling clear Plexiglas, one-sixteenth inch in thickness, for $1.00 per square foot. This price compares favorably with other price lists found in some of the catalogues of companies selling plastics and may be considered...

\(^{79}\)Ibid.
# TABLE 7

**INFORMATION CONCERNING THE SUITABILITY OF POLYSTYRENE PLASTIC AS A MATERIAL FOR USE IN AN INDUSTRIAL ARTS PROGRAM**

<table>
<thead>
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<th>Degree to Which the Plastic Meets Each Criterion</th>
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as a good indication of its price. This high cost of the material would probably tend to limit its use in the average industrial arts shop, even though it met the other criteria included in Table 7 to a favorable degree.

A sample sheet of polystyrene, one-sixteenth inch in thickness, was subjected to various processes involving the hand tools in the industrial arts shop, and it was found to be workable by most of these tools. This type of plastic did not work as well as the acrylics in every respect, however, because of a tendency to chip. It also had a tendency to clog the cutting edges of some of the tools. This may be caused by the softness of the material which was noticed especially when it was being filed. The difficulties noted above should be taken into consideration when this type of material is being considered for student use.

The above-mentioned sample sheet of polystyrene was also subjected to use involving the various power tools found in the average industrial arts shop. The jointer proved to be the most satisfactory of the power tools used for working this material, but the circle saw, band saw, and drill press were all used successfully on this material. The softness and brittleness mentioned in the preceding paragraph were also noted when the power tools were used, and as was previously mentioned, these factors should be considered before it is used in a high school shop.
Polystyrene can be cemented rather easily. Ethylene dichloride, as well as a special polystyrene cement, was tested, and it was found that both of these were very effective.

Polystyrene plastic is manufactured in many forms, such as flat sheets, rods, foamed blocks, liquid solutions, and adhesives; therefore, the average person should be able to find a form suitable for almost any type of job. The most difficult task appears to be in obtaining it on the open market. As previously mentioned, this material is more difficult to find on the open market than are the acrylic plastics.

The polystyrene sheet stock that was tested buffed very well. It took a nice polish and would be suitable in this respect for use in any small shop.

The color range of polystyrene is almost unlimited. It is prepared in all the transparent and opaque colors and also in many mottled colors. This factor should help to stimulate interest in many projects to be done by students.

The safety factor of polystyrene plastic was considered. Although this type of plastic is not dangerous under normal working conditions, it will ignite rather readily when it is subjected to an open flame.

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80Ibid.

81Dubois, op. cit., p. 108.
Polystyrene, being a thermoplastic, is easily formed. It becomes pliable and may be formed to any shape when it reaches about 180 degrees Fahrenheit, but care should be taken not to overheat this plastic, as it will melt in an oven. The sheet stock, one-sixteenth of an inch in thickness, which was tested, melted at about 250 degrees Fahrenheit; it is reasonable to assume that various thicknesses of this plastic will melt at proportionate temperatures.

Polystyrene sheet stock might be used in the high school shop if the cost of this material were lower. The few limitations of this material mentioned in the preceding paragraphs should also be considered before any great amount of money is invested in a supply of this type of plastic.

In summarizing this chapter it must be noted that the types of plastics presented—acrylic, cellulose, vinyl, and polystyrene—represent only a few of the many produced today. This study was limited because of the lack of information available concerning some of the other plastics, as well as their shortage on the market. There is a possibility that as production begins to meet the demands of industry, a great many more types of plastic materials will find their way to the general public.

When referring back to the tables included in this study, one finds that there are many types of plastic materials that could lend themselves to use in the industrial arts program. The industrial arts instructor could use the information
presented in this chapter to assist him in selecting plastic stock to be used in an industrial arts program. He should take every opportunity to experiment and to increase his knowledge of these new materials for use in general education.
CHAPTER IV

SUGGESTIONS FOR PLANNING AND EQUIPPING AN INDUSTRIAL
ARTS SHOP FOR WORK INVOLVING PLASTIC MATERIALS

When an industrial arts shop is being planned and equipped for work involving plastics as a separate course or in conjunction with some other phase of industrial arts, such as wood or metal, there are certain fundamental processes which should be considered and tools and equipment that are necessary to teach the processes. The most common processes involved in working with plastics include laying out, sawing, drilling, tapping, smoothing, buffing, fastening, forming, turning, and coloring of plastics. The subsequent planning and equipping of the industrial arts shop should evolve from the consideration of these processes.

Processes Involved in Working with Plastics
As a Material in Industrial Arts

Laying out designs on plastic stock.—There are actually three methods for laying out a design on plastic stock. One method, for use on plastic stock with the masking paper still attached, involves the use of ordinary drawing procedures. The pattern may be drawn directly on the masking paper with the use of a pencil and other layout tools that may be needed. Another method would be to draw the design
on a separate sheet of paper, cut out the design, and cement it directly on the surface of the plastic, using rubber cement. The third method involves drawing the design directly on the plastic stock. This may be done by the use of a scratch awl. This third method, however, should be used with the utmost caution, as it is very difficult to remove from the surface of the stock a scratched line if it should be located in the wrong place.¹

Sawing plastic stock.—After the design has been laid out on the stock, the stock is then ready to be cut; both the handsaw and the power saw may be used. In a small junior high school woodworking shop equipped only with hand tools, one might use the hack saw, coping saw, backsaw, or any other fine-toothed saw that may be available.² Most thermoplastics are of a fairly soft texture and will not harm the saw teeth excessively. The finest toothed saw will probably produce the most satisfactory results.

In the event that one has access to the power tools found in the average high school industrial arts shop, the jig saw and the band saw are especially useful for cutting scroll work on plastic stock, and the blades normally used for woodwork will be just as effective for plastics. The circular saw is also useful for cutting plastic stock.

¹Raymond Cherry, *General Plastics*, p. 34.
especially for ripping straight lengths and widths. It should be noted that the power saw blades should have fine teeth and that the processes and procedures for cutting plastics with these saws are the same as those used for cutting wood. Groneman, however, suggests the setting aside of a separate blade for each saw if there is an excessive amount of plastic to be cut.  

Drilling and tapping plastics.--The drilling of holes in plastics may be accomplished in much the same manner as with wood or metal. The simplest hand drill press may be used. The scratch awl should be used to center punch the hole to prevent the bit from wandering. When a hole is being drilled in plastic stock, the bit should be withdrawn from the hole frequently to prevent clogging and heating of the plastic and the drill bit. If a drill press is used, a slow speed should be used to prevent overheating. When holes are being drilled in plastics, as with other materials, there may be times when some type of lubricant should be used; in this event a solution of a mild soap and water may be ample.  

Tapping and threading of the various types of plastics suitable for use in industrial arts programs is oftentimes necessary. The use of the "National Coarse" thread has been found to be the most satisfactory. Either hand or machine

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3Chris H. Groneman, Plastics Made Practical, pp. 45-46.

4Cherry, op. cit., p. 38.
methods may be employed for tapping or threading plastic stock. The use of standard tapping and threading procedures used in metal work should be followed in working with plastics, and a standard tap and drill chart should be consulted as to the size hole to be drilled for a given size tap.5

**Dressing the edges and surfaces of plastic stock.** After the project has been cut roughly to size, there remains the task of smoothing, sanding, and buffing the edges. The smoothing of the edges may be accomplished by one of three methods. One method for smoothing the edges is by the use of the ordinary fine-cut flat mill file; other shapes of files may be needed for reaching into corners or small edges of scrollwork. The other two methods of smoothing the edges of plastic stock are the ordinary hand plane and the power jointer; both of these may be used very effectively where long, straight edges may be encountered.6

The sanding of the edges after they have been smoothed is usually completed in three operations. The first operation involves the use of a rough, wet-or-dry sand paper, usually about a Number 120 grit. This operation is followed by another sanding with wet-or-dry paper of about a Number 220 grit; if a fine luster is desired, the edges are usually finished with a wet-or-dry sandpaper of a Number 400 grit.7

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5DeWick and Cooper, op. cit., p. 51.
The final finishing of the edge surfaces is usually obtained with the use of a cloth buffing wheel. Although most plastic materials may be buffed satisfactorily by hand, a power-driven buffing wheel is much more efficient. The best polishing abrasives for use on the cloth buffer are tripoli, rouge, and aluminum oxide. The final finish, however, is obtained with a dry buff to eliminate any scratches caused by the grit of the abrasives.8

**Fastening of plastic stock.**—Because of the nature of some projects found in the industrial arts shops where there are frequently a number of parts to assemble, some method must be used to develop a substantial joint. The two most common methods for joining plastics are the use of machine screws and cementing. If machine screws are used, a hole must be drilled and tapped to allow the screws to hold in the plastic.9 When a cement joint is made, a plain solvent designed for cementing plastic stock may be used. The solvent bonds the pieces of plastic together, and the joint is usually complete as soon as the solvent evaporates.10

**Forming of plastic stock.**—The thermoplastics, as previously mentioned, have the ability to become soft and pliable at about 200 degrees Fahrenheit and can be bent, formed,

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8Ibid., p. 51.
9Cherry, op. cit., p. 39.
10Lockrey, op. cit., p. 68.
or molded into almost any desired shape. When thermoplastics cool, they retain the shape to which they have been formed and will retain a given shape until they are heated again. The patterns or dies used to form thermoplastics may be made of a soft wood and covered with felt. Dies may be used many times, thereby allowing the industrial arts instructor to obtain a large selection.11

Turning of plastic stock.—Plastics may be turned on the various types of wood and metal lathes without much difficulty. The cutting tools must be kept extremely sharp, and a steady rest for the cutting tool must be used. The correct speeds for turning plastic stock will differ according to the type of plastic material being turned. A good rule to follow is that the feed and speed should correspond to those used in turning brass. The craftsman should be familiar with the operation and limitations of the machine used for turning wood or metal and should adhere to the operations and limitations when he is turning plastics.12

Coloring of plastic stock.—Oftentimes, the industrial arts instructor may be confronted with the problem of obtaining several different colors of plastics. This could prove expensive if a supply of each colored plastic produced were kept on hand. To alleviate this situation, it

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12 DeWick and Cooper, op. cit., p. 55.
is possible to purchase both cold and hot dyes for color-
ing plastic materials that may be used in the school shop. The use of these dyes makes it possible for the student to color plastic materials to any desired shade, as well as any color. These dyes may be purchased from many of the plastic supply houses. The procedure to be followed in using different types of dyes is usually explained by a set of directions supplied by the company producing the product.13

Tools and Equipment Needed to Complete the Processes Usually Involved in Working with Plastics

The tools and equipment needed for the working of plastics may be varied, depending upon the type of plastics used and the processes that will be involved in fabricating articles from the plastic stock. There are, however, certain tools which are essential for working with plastics in the industrial arts shop. Some suggested tools and the processes to which they are related are listed as follows:

I. Tools for use in layout work

1. Rule—A 12 inch or 24 inch straight-edge rule may be used.

2. Pencil—Any medium or soft lead pencil is sufficient.

13Groneman, op. cit., p. 32.

4. Dividers--A pencil compass may also be used if the masking paper is on the plastic.

5. Try square--Any type square found in the general shop may be used.

II. Tools for sawing plastics

1. Coping saw--This type saw is used principally for cutting irregular shapes.

2. Back saw--This type saw may be used for cutting straight edges.

III. Tools used for drilling, tapping, and threading of plastics

1. Hand drill--Any type hand drill used on wood or metal may be used.

2. Drill bit--A selection of various sizes of metal drill bits would be helpful.

3. Tap--A small set of junior size N C (National Course) taps with the handle should be suitable.

4. Threading--A small set of junior size N C (National Course) dies will prove useful for threading plastic rods.

IV. Tools for smoothing, sanding, and buffing of plastics

1. File--Either a metalworking or woodworking file is suitable for dressing the edges of
plastics; however, a smooth, fine-cut, flat
file may be preferred.

2. Needle file—Delicate needle files are es-
specially useful for finishing pierced and
intricate designs.

3. Sandpaper—A supply of wet-or-dry sandpaper
of about a Number 120 grit, Number 220 grit,
and Number 400 grit should be on hand.

4. Buff—A hand buff may be used.

V. Tools and equipment used in forming plastics

1. Oven—Any oven which will heat to 250 degrees
Fahrenheit will be suitable for most plas-
tics. One limitation to consider is the
size of the project.

2. Flat iron—In the event that an oven of the
above type is not available, very satisfac-
tory forming may be done on an inverted
ordinary electric iron.

VI. Equipment used in turning plastics

1. Lathe—Any wood or metal lathe may be used;
however; the metal lathe may be preferred.

2. Lathe tool—A selection of lathe tools will
depend on the type lathe being used and on
the operation to be performed.

VII. Equipment used for coloring plastics
1. Cold dyeing—An earthenware crock or porcelain-lined utensil may be sufficient for dip dyeing.

2. Hot dyeing—A metal container may be used unless otherwise recommended by the type of dye being used.

The above list of tools and supplies is considered necessary in order actually to complete the usual processes involved in working with plastics as listed at the beginning of Chapter IV. If any of the processes should be eliminated because of the nature of the work involving plastics, the tools and equipment suggested for each process naturally would not be needed.

Miscellaneous tools and equipment considered helpful but not essential for working plastics. As previously stated, power tools are not absolutely necessary to work with plastics, but their use may prove especially helpful and should increase the speed of production. If new equipment is to be purchased, sturdy, light-weight equipment is suggested; however, if the present equipment located in the industrial arts shop is to be used, it will also prove satisfactory, generally speaking, regardless of size.\(^{14}\)

The following is a list of power equipment which is considered helpful in the working of plastics. This

\(^{14}\)Groneman, op. cit., p. 37.
equipment is listed alphabetically and not necessarily in order of importance.

Band saw
Belt sander
Buffer
Circular table saw
Disk sander
Drill press
Handee electric drill
Jig saw
Jointer
Lathe, metal cutting
Lathe, wood cutting
Lettering machine
Vibro-tool, electric

Adapting Present Physical Facilities for Work with Plastics

When faced with the situation of beginning a new course, the instructor, as well as administrative officials, should consider the type and size of physical facilities which might be needed. With the ever-increasing enrollment in the public schools, the problem of room and shop space is an ever-growing one. In situations where adequate space is a problem, one should study the present facilities and attempt to determine how they could be utilized most advantageously.
Adapting an ordinary classroom for work with plastics--
One of the usual facilities that might be considered is the ordinary classroom. The present seating facilities may have to be removed and tables or sturdy workbenches substituted. Stools should be provided for seating the pupils, as they are usually higher than the ordinary chair, thus allowing the student to be in a better position to work.
Another consideration when an ordinary classroom is being altered for work with plastics should be space for the tools, as well as storage space for supplies and student projects. The classroom at best would provide limited facilities for teaching plastics as a phase of industrial arts. However, the ordinary classroom should not be overlooked if it is impossible to provide anything more suitable.

Adapting a drawing room for work with plastics.--
Another area that can be adapted for class work in plastics is the drawing room. In most instances the benches and stools are already provided. Usually there still remains the problem of providing a space for the necessary tools and equipment, as well as storage for supplies and space for student projects. However, it is possible to adapt a drawing room for drawing and for classes involving the use of plastics. This is one way in which to utilize a schoolroom every period of the day rather than just part-time.
Adapting a general shop for work with plastics.---One of the more satisfactory places for beginning a class in plastics is in the general industrial arts shop. Plastics can be included in the general industrial arts program, thereby utilizing the shop facilities to a greater extent. The benches, stools, tools, storage space, and student locker space usually found in a general shop could very well be used for work in the area of plastics.

Adapting the unit shop for work with plastics.---In a shop program where wood or metal is taught on a unit basis, one should consider these facilities as strong possibilities for work in the area of plastics. In the average unit shop, bench space, a tool room, material storage, and a place for student projects are usually provided. This space may suffice for a unit of work in plastics, as well as in the other industrial arts courses offered. In the event that the present facilities for a unit shop are already crowded, there is the possibility that they could be slightly enlarged. Under some circumstances, this would be cheaper than trying to provide for a complete new laboratory for work with plastics.

Suggestions for Use in Planning and Equipping New Laboratories for Work in the Area of Plastics

There are times when an industrial arts teacher has the opportunity to help plan a building and other facilities for industrial arts. Richard G. Strickland conducted a study
in 1952 that was concerned with the housing facilities of industrial arts shops. Strickland charted the recommendations of five authorities in the field of schoolhousing and formulated a set of standards for use in planning the housing facilities for an industrial arts shop.

The ideal industrial arts shop as described by Strickland should meet the following specifications. The shop should be located on the ground level, and there should be a minimum of fifty square feet of floor space per pupil. The floor should be constructed of reinforced hardwood, and there should be a minimum light reading of twenty-five foot-candles at all work stations. There should be space for a shop library. Other recommendations by Strickland included such features as a class demonstration area, an outside truck entrance, a sink for washing facilities, a window area with a ratio of one square foot of glass for each five square feet of floor space, an efficient heating arrangement, a sufficient number of electrical outlets, an office for the instructor, and safety devices provided and clearly marked.16


16Ibid., p. 17.
CHAPTER V

SUMMARY, FINDINGS, AND RECOMMENDATIONS

Summary

The purpose of this study was actually sevenfold and is briefly restated as follows: first, to review the literature and information available concerning the various types of plastics; second, to study and present data and information available with respect to the various types of plastics available for use in industrial arts programs; third, to devise ways and means and/or to develop criteria that can be used as a guide by industrial arts teachers to assist them in determining what type or types of plastics are best suited for use as a material in industrial arts programs; fourth, to study the various types of plastics to ascertain the types best suited for use in construction of projects by students enrolled in industrial arts courses; fifth, to offer suggestions and ideas with respect to planning a suitable industrial arts laboratory for students working with plastics; sixth, to compile a list of dealers who cater to the selling of plastics to industrial arts programs and home craftsmen; and seventh, to compile a list of supply houses and dealers from whom instructional materials may be obtained for use in the teaching of plastics.
The study was organized into five chapters. Chapter I includes the introduction to the study and the purpose of the study. The chapter also includes the limitations of the study, source of data, information from some recent and related studies, and the definition of terms considered pertinent to the study.

Chapter II treats the development of the plastics industry. Information concerning the early discoveries in the field of plastics, the need for plastics in our everyday living, and the importance of consumer education for the general public was also presented.

Chapter III contains criteria which were developed for use in determining which types of plastics are probably best suited for use in an industrial arts program in a high school shop. The acrylic, cellulose, vinyl, and polystyrene plastics were evaluated through use of the criteria and information concerning the use or probable use of each of these plastics as a material in industrial arts shops.

In Chapter IV information considered necessary for use in planning and equipping present industrial arts shop facilities for a course in plastics was presented. The processes most commonly used in the working of plastics were presented, as well as the tools necessary for performing these processes in order to show how the equipment and tools found in the average industrial arts shop can be used for plastics. Other information in this chapter included
the tools which would prove useful but which were not necessarily essential to work with plastics, hints on the possible conversion of other present facilities such as drawing rooms and ordinary classrooms for a course in plastics, and some recommendations from other research studies concerning items to be considered when a complete new building is being planned for industrial arts.

Chapter V contains a summary of the study, a list of findings, and some recommendations based on the results of the study.

Findings

Based upon the results of this study, the following findings are offered.

1. Plexiglas and Lucite meet to a high degree the criteria that were developed and set forth in the study. The two plastics are considered as suitable for use in the construction of projects in industrial arts programs.

2. Cellulose nitrate can be used with certain limitations in a high school shop; it is highly combustible, however, and should be considered as dangerous for high school students to use.

3. Cellulose acetate and cellulose acetate butyrate plastics were found to be acceptable as a material for high school use.
4. Because of the lack of information available, an extensive evaluation of ethylcellulose plastics could not be made, and no recommendations based upon the results of this study concerning the suitability of this type of plastic for use in industrial arts programs are offered.

5. The vinylite plastics conformed to the criteria used in the study to a moderate degree, but this type of plastic is not readily available and is slightly more expensive than the acrylic plastics.

6. Polystyrene was found to conform to the criteria to a moderate degree; however, the cost of this type of plastic, which is greater than either the acrylics or the vinylite, would tend to make its use in the high school shop somewhat limited.

7. Plastics are one of the major industries of the United States.

8. There are many types of plastics available to the general public, and there is a need for a better understanding of these plastics.

9. Because of the many types of plastics available, there is a need for a better understanding of these types of plastics by the average industrial arts instructor before he undertakes the teaching of a course involving the use of plastic stock.

10. The industrial arts instructor should ascertain which type of plastic will be best suited for an industrial
arts program before he invests a great amount of money in plastic materials, because some types are not suitable.

11. Plastics can be introduced into an industrial arts program without undue cost.

12. Ordinary classrooms used for instructional purposes other than industrial arts could be readily adapted for a course in plastics.

13. Many of the tools and much of the equipment already in use in the average industrial arts shop can be used for a course in plastics.

Recommendations

1. Plexiglas and Lucite are both recommended for use as a material in a high school industrial arts program.

2. Cellulose nitrate is not recommended for use in the high school program because of its inflammability.

3. Cellulose acetate and cellulose acetate butyrate are recommended for use in the high school shop if they are available to the instructor.

4. Vinylite is not as highly recommended for use in the high school shop as are the acrylic plastics at this time because of the relatively high cost of vinylite.

5. Polystyrene is not recommended for use in the high school industrial arts program at this time because of its high cost as compared with Plexiglas and Lucite.
6. In view of the increasing importance of plastics to the present economy, more instructional activity involving plastics should be taught in the schools.

7. A greater effort should be made to design new projects that would involve the use of plastics.

8. The use of plastics should be incorporated into the other phases of industrial arts, such as wood or metal.

9. A course in high school plastics should contain a substantial amount of material designed for teaching consumer education.

10. The industrial arts instructor should check thoroughly into the field of plastics before selecting any certain type of plastic material for use in an industrial arts program.

11. Instructors should consult trade magazines as well as hobby and craft publications as a source for suggested projects.
APPENDIX A

RETAIL DISTRIBUTORS OF PLASTICS AND PLASTICS SUPPLIES

A & A Plastic Supply Company, 4308 Maple Avenue, P. O. Box 6773, Dallas 19, Texas.

A M C Supply Company, 1400 Henderson Street, Fort Worth, Texas.


Brodhead-Garrett Company, 4560 East 71st Street, Cleveland, Ohio.

Cadillac Plastic Company, 15111 Second Avenue, Detroit 3, Michigan.

Commercial Plastics and Supply, 630 Broadway, New York 12, New York.

Craft Service, 337 University Avenue, Rochester 7, New York.

Craft Shop, 124 Ford Avenue, Wyandotte, Michigan.

Fry Plastics Company, 7826 South Vermont Avenue, Los Angeles, California.

Gem-O-Lite, 5350 Riverton Avenue, North Hollywood, California.

Hobby Supply House, P. O. Box 2014, Pittsburgh, Pennsylvania.

Leisurecrafts, 907 South Hill St., Los Angeles 15, California.

Plasticast Company, P. O. Box 6737, Chicago 80, Illinois.

Plastic Parts and Sales, 1157 South Kingshighway, St. Louis, Missouri.

Plastics Center, 317 Nogalitos Street, San Antonio 4, Texas.


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APPENDIX B

COMPANIES WHICH SUPPLY FREE AND INEXPENSIVE MATERIALS
USEFUL IN TEACHING A COURSE IN PLASTICS

American Cyanamid Company, Plastics Division, 30 Rockefeller Plaza, New York, New York.

Bakelite Company, 30 East 42nd Street, New York 17, New York.

B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.


Celanese Celluloid Corporation, 180 Madison Avenue, New York, New York.

Dow Chemical Company, Plastics Division, 2000 Main Street, Midland, Michigan.

Durez Plastics and Chemicals, Inc., 875 Walck Road, North Tonawanda, New York.


Fry Plastics Company, 7606 South Vermont Avenue, Los Angeles, California.

Hungerford Plastics Corp., 102 Central Avenue, Murray Hill, New Jersey.

Magic Chemical Company, 125 Crescent Street, Brockton 2, Massachusetts.

Masland Duraleather Company, Amber and Westmoreland Streets, Philadelphia 34, Pennsylvania.

Monsanto Chemical Company, Plastics Division, Springfield, Massachusetts.

Nixon Nitration Works, Nixon, New Jersey.
Libbey-Owens-Ford Glass Company, Plaskon Division, 2122 Sylvan Avenue, Toledo 6, Ohio.


Tennessee Eastman Corporation, Kingsport, Tennessee.
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