# A STUDY OF THE DEVELOPMENT AND USE OF PLASTICS IN INDUSTRY WITH PROPOSALS FOR THE ADAPTATION OF PLASTICS AS A PHASE OF INDUSTRIAL ARTS

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# CHAPTER I

## INTRODUCTION

One of the latest, yet one of the fastest growing, industries in America today is the plastics industry. Though some types of products still used today were developed in the middle of the nineteenth century, the modern plastics industry began shortly after 1920, survived the depression years, and then reached what many thought to be its peak during the war years. The plastics industry disproved this by continuing to grow each year after the war ended and has not as yet reached the leveling-off point. With demand for its products increasing each year, plastics are now a permanent major industry with an excellent future.

### Statement of Problem

The problem is to make a study of the development and use of plastics in industry with proposals for the adaptation of plastics as a phase of industrial arts.

### Purpose of the Study

The purpose of this study is twofold. First, it is to present evidence of the ever-increasing development and use of plastics by industry. A second purpose after presentation of evidence, is to propose that industrial arts must adapt work with plastics as a phase of its program in order to meet present-day needs of the growing generation.

## Delimitations

With the exception of the origin and early development of plastics in Europe presented inChapter II, this study is limited to the development and use of plastics in the United States. The study is further limited in being primarily concerned with products of the plastics industry rather than with the combination of ingredients and chemical processes necessary to make these products.

## Method of Procedure

A review of the literature was made to find the historical background of plastics, the present stage of advancement of the plastics industry, and the variety of uses for plastics at the present time. During this review of literature, special attention was given to magazine articles written by instructors of industrial arts who had developed courses in plastics to find the teaching results which the instructors had obtained and the pupil interest in courses of this type.

Chapter I is an introduction to the study and contains the statement of problem, the purpose of the study, the delimitations, method of procedure, the source of data, the definition of terms, and a survey of recent literature and related studies.

The development of plastics including their origin, the rise of the industry to its present level, the factors that influenced this rise and statements from various sources concerning the outlook for the future of plastics are the topics that make up the content of Chapter II.

Uses of plastics by industry, in architecture, and by individuals are included in Chapter III.

Through analysis of the objectives of general education and the objectives of industrial arts, Chapter IV. states the need for plastics in fulfilling these objectives. Secondly, Chapter IV presents a proposal for the adaptation of plastics as a phase of industrial arts with suggestions as to how this can be accomplished.

Chapter V contains a list of conclusions and some recommendations offered in the light of the data presented.

## Source of Data

The data used in this study were obtained from periodicals, books and pamphlets pertaining to the plastics industry. Statistical figures regarding plastics production were furnished by the Society of the Plastics Industry, Inc., based on government publications of the United States Tariff Commission. Other useful information was secured from literature received from manufacturers and users of plastic products.

## Definition of Terms

Many new terms have been originated by the plastics industry while other terms have taken on new meaning when used in relation to plastics. Illustrative of this is the term "plastic" itself which is defined by Webster's dictionary as "capable of being formed or molded." The foregoing definition is too general for the current application of the term. "Plastic" and other terms pertinent to the study are defined as follows:

The term "plastic" in the light of present-day use of the word has been defined as a synthetic organic material whose chief component is a resinous or cellulose derivative binder. At some stage in its production it is either plastic (capable of being shaped) or liquid (capable of being cast) and at some subsequent stage it assumes a more or less rigid condition.[1] This definition is used in the study, thus excluding such natural plastics as clay, pitch, and shellac.

"Synthetic resin" is used throughout the study as a synonym for the term "plastic."

The term "extrusion" has been defined as a method of processing plastic in a continuous or extended form by forcing heat-softened plastic through an opening-like cross section

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[1] Simonds, Weith, and Bigelow, <u>Handbook of Plastics</u>, p. 2.

of the finished product.[2] This definition applies throughout the study where the term "extrusion" or its synonym "extruded section" is used.

The term "laminate" indicates a flat sheet or board made by bonding together with plastic a number of sheets of paper, fabric, or other materials.[3]

The term "adaptation" means an alteration of an existing situation to include certain changes made necessary by new developments.

Survey of Recent Literature and Related Studies

A number of articles have been written by instructors of industrial arts who have developed courses in plastics or units in their general shop course using plastic materials. One of the earliest articles available regarding the use of plastics in a school shop was published in 1937 and written by A. R. Skomp of Rocky River High School, Rocky River, Ohio.[4] One of the main difficulties faced by Skomp was getting plastic materials for use in the school shop because of their high price. A teacher using plastics today will not encounter this problem since a ready supply of plastic materials is available at reasonable prices. In regard to the most

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[2]Plastic Materials Manufacturers Association, How to Buy and Sell Plastics, p. 33.

[3]Ibid.

[4]A. R. Skomp, "Use of Plastics in Our Industrial Arts Shops," Industrial Arts and Vocational Education, XXVI (June, 1937), 193-194.

economical form of material to use in a school shop, Skomp states the following:

> Although cast plastics for fabrication may be higher than material for molding, if bought by the pound, the final cost is lower because of the fact that cast plastic may be worked with ordinary shop tools and machines. Now that industrial arts instructors see the possibilities for the use of plastics in the school shop, no doubt the industry will cooperate in every way to give the shop teacher cast blanks suitable for student requirements. [5]

Another difficulty was that satisfactory glue had not at that time been developed for use with plastics. Skomp used ambroid with fair results. Some metal glues were also satisfactory. Best results were obtained from a glue sold by a plastics manufacturer though care had to be taken to dilute it with the proper amount of hydrochloric acid to prevent unsatisfactory results. Projects were limited to the stock available from manufacturers and were usually smaller articles such as rings, paper knives, and brooches. Skomp concluded that plastics, if properly used, would do much toward stimulating the industrial arts program.[6]

Coleman Hewitt published a more recent article in 1948 in regard to the use of plastics in the home mechanics and

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[5] *Ibid.*, p. 194.

[6] Coleman Hewitt, "Plastics in the Schools," *Chicago Schools Journal*, XXIX (January, 1948), 53-56.

industrial arts courses in the Chicago Public Schools.[7] Regarding the use of plastics in schools, Hewitt makes the following statement:

> Since this has been called a plastic age, perhaps it would be logical to use the material in the schools. Wood, paper, metal, and textiles have long been in common use in the schools, and if courses are to be kept up-to-date, these materials should be used.[8]

Plastics were introduced in the schools of Chicago during the war when wood and metal were difficult to obtain, and quantities of plastic scraps were readily available for use in the school shops. Since plastic materials are now available through the supply department, scrap plastics need no longer be used. The popularity of plastics has continued to grow as more teachers become aware of its possibilities.

In summarizing the advantages of using plastics in industrial arts classes, home mechanics classes, and craft activities, Hewitt lists the following:

1. It is a new and modern material.
2. No coats of finish are necessitated.
3. It is relatively low in cost.
4. Projects can be completed speedily.
5. Its gem-like sparkle and color are attractive.
6. Only simple and inexpensive tools and equipment are needed.
7. It can be formed into artistic shapes easily.
8. The material is readily available.
9. There are many different kinds of plastics to fit many different purposes.[9]

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[7] *Ibid.*, p. 54.

[8] *Ibid.*

[9] *Ibid.*, pp. 55-56.

Hewitt predicted that eventually there will be a plastics unit in the Chicago school shops similar to those in wood and metal now being taught.[10]

Stanley F. Schneck reported favorable results in the use of Lucite and Plexiglas in industrial arts classes at Coopersburg, Pennsylvania.[11] Advantages and desirable outcomes of working with these two plastics were summarized as follows:

> Lucite and Plexiglas are undoubtedly the most versatile of all fabricating materials. They may be worked like wood but won't warp; worked like metal but won't tarnish. Both may be cemented into a permanent joint or shaped to any desired form or be dyed any color. No other medium offers a better chance to apply creative design to such a high degree.
>
> Working with plastics provides a basic yet general understanding of the processes and materials used in industry. The pleasure and relaxation acquired in working with this substance provides a worth-while leisure time interest. [12]

Schneck lists six major processes in working with Lucite and Plexiglas. These methods are sawing, sanding and buffing, heating, cementing, dyeing, and undercutting or internal carving.

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[10] *Ibid.*, p. 55.

[11] Stanley F. Schneck, "Course in Plastics," *Industrial Arts and Vocational Education*, XXXVII (March, 1948), 114-115.

[12] *Ibid.*, p. 114.

Louis Nisgore of Bensonhurst Junior High School, New York City, New York, introduced the use of Lucite and Plexiglas in the metalwork shop during the war and is continuing their use during peacetime. Desirable aspects of working with plastics include their wasy workability, the minimum of tools necessary, and the ready availability of Lucite and Plexiglas from handicraft supply houses. In addition, these plastics can be worked almost entirely with hand tools which is advantageous from the standpoint of safety. Plastics hold student interest and have a stimulating effect on students because of the number of projects that can be easily completed.[13]

Although no studies dealing with the specific subject of this study are available, two studies related to the subject were used to a limited extent. Gerald S. Brenholtz[14] made a study to analyze the handicrafts program to find its function in education for life adjustment situations. His study dealt with the handicrafts program in general while this study is concerned with adapting plastics as a phase of handicrafts in the industrial arts program along with other uses such as upholstery and its uses when combined with wood

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[13] Louis Nisgore, "Use of Plastics in Our Industrial Arts Program,"<u>High Points</u>, XXIX (September, 1947), 79.

[14] Gerald S.Brenholtz, "An Analysis of the Function of Handicrafts in Education for Life Adjustment Situations," Unpublished Master's Thesis, Department of Industrial Arts, North Texas State College, 1949, pp. 1-64.

or metal. Brenholtz discussed briefly the use of plastics in handicrafts and listed some possible projects. Part of the conclusions Brenholtz reached are as follows:

> 1. Handicrafts can fill an important place in education for life adjustment education. It should be of value in helping the student develop skills and understanding that will help him to earn a better living.
> 5. Handicrafts will give the student an opportunity to experiment with many materials new to him while in search of an occupation suitable to fit his needs. [15]

In addition to the two materials, wood and leather, used extensively in crafts programs, plastics have characteristics that will make them a popular addition to any handicraft course.

Emma L. Sealy[16] made a study in 1946 on the subject of plastics and presented a summary of their history and their uses in war and peace. A part of the study was devoted to a discussion of chemical compounds and manufacturing processes used in making plastics. The study contained a list of the types of plastics with their trade names and the possible applications of each type.

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[15] Ibid., pp. 62-63.

[16] Emma L. Sealy, "Plastics, Their History and Use," Unpublished Master's Thesis, Department of Education, North Texas State College, 1946, pp. 1-47.

## CHAPTER II

## THE DEVELOPMENT OF THE PLASTICS INDUSTRY

Contrary to a rather popular belief, plastics are not new. The first synthetic plastic was discovered in France over a hundred years ago, and the industry has advanced at irregular intervals since that time. Important contributions in the development of plastics have been made by both European and American scientists. Although plastics originated in Europe, the first commercial development was begun in the United States, and the plastics industry in the United States today has a greater production than any other country in the world.

### The Origin and Early Development of the Plastics Industry

All plastics fall in one of two major divisions, thermosetting or thermoplastic. The basic difference between these two divisions is that thermosetting plastics cure or set under the action of heat and cannot be re-melted, while thermoplastic plastics soften by re-heating and can be re-melted or re-molded.[1] There are more than thirty types of

[1] Simonds, Weith, and Bigelow, *op. cit.*, p. 2.

plastics which fall in one of these two categories. In 1950 there were 672 registered trade names for plastic materials ranging from Acele to Zyrox.[2] The first plastic belonged to the thermoplastic group, whereas the first thermosetting type of plastic was not developed until seventy-six years later.

<u>The first thermoplastic</u>.--The plastics industry had its origin in the earlier half of the nineteenth century in the work of Braconnot in France in 1833 and Schoenbien, a professor in the University of Basil, Switzerland, in 1845, through the discoveries related to the preparation of cellulose nitrate.[3] Their work remained unused commercially until a shortage of ivory for billiard balls caused a prize of $10,000 to be offered to anyone who could produce a synthetic ivory. John Wesley Hyatt, an American, accomplished this in 1868 by mixing nitric acid and cellulose to produce cellulose nitrate, the first thermoplastic for commercial use. This material later became known as celluloid or Pyralin Ivory. A patent was granted to Hyatt and his brother Isaiah in 1869.[4] Because this plastic, celluloid, could be

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[2] <u>1950 Modern Plastics Encyclopedia and Engineer's Handbook</u>, pp. 1187-1195.

[3] Simonds, Weith, and Bigelow, <u>op. cit.</u>, p. 3.

[4] Coleman Hewitt, <u>op. cit.</u>, p. 54.

molded at comparatively low temperatures and set quickly at ordinary room temperatures, it was ideal for the forming of dentures.[5] As a result, the Albany Dental Plate Company was formed in 1869 to handle production and sales of this material. The demand for celluloid for miscellaneous uses was greater than expected so the Celluloid Manufacturing Company was formed in Albany, New York, in 1871 to take over this thriving business. This company was moved to Newark, New Jersey, in 1872, and this is still its present location.[6]

Discovery of the first thermosetting plastic.--The first thermosetting synthetic resin was developed by Dr. Leo H. Baekeland of Yonkers, New York, and was patented in 1909. Baekeland mixed phenol and formaldehyde to produce this material known as "Bakelite." He began production of bakelite in his laboratory as early as 1907 but because of an increased volume of sales, the General Bakelite Company was formed in 1910. The original company was merged in 1922 with the Redmanol Chemical Products Company of Chicago and the Condensite Company of Bloomfield, New Jersey. This merger caused the name of the firm to be changed to the

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[5] B. W. Leyson, Plastics in the World of Tomorrow, p.44.

[6] Simonds, Weith, and Bigelow, op. cit., p. 3.

Bakelite Corporation. A later merger with the Union Carbide and Carbon Corporation was effected in 1939 and at this time the name Bakelite Corporation was retained and became the Plastics Unit of the corporation.[7]

<u>Results of Baekeland's discovery</u>.--The material developed by Baekeland shaped the course of many industries and paved the way for the large growth that the plastics industry has since experienced. The new material, Bakelite, offered the industrial world, and especially the electrical industry, an insulating material which could be molded into intricate shapes, with desirable physical and electrical properties, good mechanical strength, and excellent appearance.[8]

<u>Development of cellulose acetate</u>.--A period of very active development of new plastic materials in the United States followed, beginning with the appearance of cellulose acetate in 1927. This plastic had been known for many years prior to that date with its first preparation dating back to 1865. It was first commercially introduced in the United States by the Celluloid Corporation in the form of rods, sheets, and tubes.[9]

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[7] <u>Ibid</u>., pp. 3-4.

[8] J. H. Du Bois, <u>Plastics</u>, pp. 2-3.

[9] Gordon M. Kline,"History of Plastics and Their Uses in the Automotive Industry," <u>Modern Plastics</u>, XVII (August, 1940), 58.

<u>Development of vinyls and acrylics</u>.--Two other examples of plastics which had been known for a number of years before they were commercially developed are the vinyls and acrylics. Vinyls were known for over a hundred years before they were first made in the United States by the Union Carbide and Carbon Chemical Corporation under the trade name "Vinylite" in 1928.[10] The acrylic resin plastics became available in quantities only through development by industrial research and were first commercially prepared by Rohm and Haas Company with the introduction of "Plexiglas" in 1936 and "Crystalite" in 1938.[11] The Du Pont Company in 1937 placed another acrylic, "Lucite," on the market. Characteristics of the acrylics are their colorless transparency, adhesive qualities, elasticity, and stability to light, moderate heat, and weathering.

<u>Types of plastic materials</u>.--Since a complete discussion of each of the more than thirty types of plastics is not practicable in this study, the most important and typical materials of the plastics industry are presented in the following table.

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[10] <u>Ibid</u>., p. 61.

[11] <u>Ibid</u>., p. 80.

TABLE 1

SYNTHETIC PLASTIC MATERIALS[12]

Thermosetting Materials

| Chemical name | Common name | First used commercially |
|---|---|---|
| Phenol-formaldehyde | Phenolics | 1909 |
| Urea-formaldehyde | Ureas | 1930 |
| Melamine-formaldehyde | Melamines | 1940 |

Thermoplastic Materials

| Chemical name | Common name | First used commercially |
|---|---|---|
| Cellulose nitrate | Nitrates | 1868 |
| Cellulose acetate | Acetates | 1927 |
| Cellulose acetate butyrate | Butyrates | 1938 |
| Ethyl cellulose | Ethylcell | 1936 |
| Polystyrene | Styrenes | 1937 |
| Methyl methacrylate | Acrylics | 1936 |
| Vinyls | Vinyls | 1928 |
| Nylon | Nylon | 1938 |

The materials shown in Table 1 are representative of the more than thirty types of plastic materials which form the basis for the fast-growing plastics industry in the United States. New uses for these plastics develop each year.

[12] Clark N. Robinson, Meet the Plastics, p. 13.

## Rise of the Plastics Industry

### Increase in Plastics Production

No figures are available on the production of plastics prior to 1922 for the industry was in its infancy before that time. The picture in the plastics industry before 1920 is summed in in this statement.

> Companies producing [plastic] moldings before the 1920's, such as General Electric, Westinghouse, and Continental-Diamond Fibre did so almost entirely for their own consumption. Electrical insulation was the chief market until the demand for silent gears caused the General Electric Company (and some other companies) to begin manufacture of other fabricators.[13]

Basic patents held by Baekeland did not expire until 1926 when a number of companies began producing phenol-formaldehyde plastics under a variety of trade names.[14]

Plastics production from 1922-1950.--An overall picture of the growth in the production of plastics is shown in Figure 1 which covers the amount of plastics in pounds produced each year since 1922 with the exception of the years 1923 through 1926. In comparison with production figures, the sales of plastics in dollars in 1927 was $30,000,000 at a price of eighty-one cents a pound.[15] In 1948 the sales were $368,476,000 at a price of thirty cents a pound.[16]

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[13] Simonds, Weith, and Bigelow, op. cit., p. 1.

[14] D. E. Mansperger and C. W. Pepper, Plastics, Problems, and Processes, p. 8.

[15] Simonds, Weith, and Bigelow, op. cit., p. 13.

[16] 1950 Modern Plastics Encyclopedia and Engineers' Handbook, p. 1096.

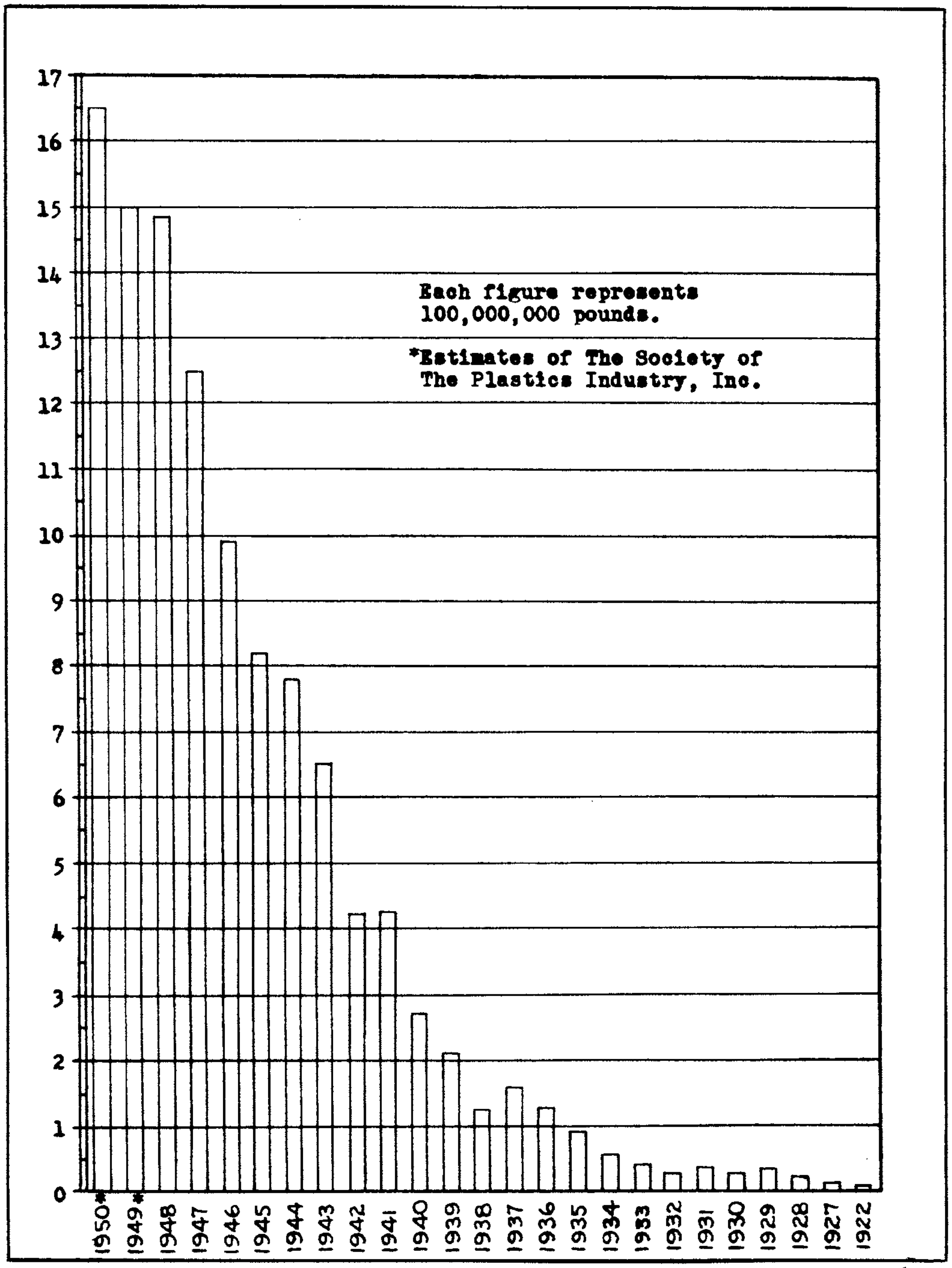


Fig. 1.--Plastics production from 1922-1950 16 a

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16 a
"Synthetic Resin Production," The Society of the Plastics Industry, Inc., 1950. Mimeographed.

Significant data brought out by ~~Table 2~~ figure 1 are, first, that plastics production has grown steadily during the period covered, with the exceptions of the years 1930, 1932, and 1938; second, the phenomenal increase in production that occurred during World War II has more than doubled in the post-war period.

The Pre-War Plastics Industry

The upswing of American industrial activity during the 1920's was responsible for the early expansion of the plastics industry. Specialists began to appear in all fields of the plastics business from the individuals working in their own shops to the large manufacturers of chemicals, resins, and finished products. Each new development in plastics caused new groups of manufacturers to enter the picture.[17] This pace continued through 1929 when plastics reached 33,036,490 pounds but was destined for a moderate decline in 1930 when production was only 30,867,752 pounds.[18] The following statement contemporary with the 1930 decrease in plastics production gives the reason for this decline:

> Among the principal products and, therefore, major producers, the plastics industry experienced a

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[17] General Electric Corporation, What Are Plastics, p. 4.

[18] "Synthetic Plastics Production," (The Society of the Plastics Industry, Incorporated, 1950), Mimeographed.

> deceleration from its pace of 1930 in sympathy with its primary outlets, mainly a producer's demand in such young industries as the automobile, electrical and radio. Most affected were the smaller companies because of their lesser financial adaptability. The leaders by other standards than 1929 had a really tolerable year, while new technical developments were only slightly affected by unfavorable marketing conditions. On the whole as a new industry in the scheme of affairs, plastics manufacture may be said to have had a lull in its growth due to temporary undernourishment, but it will hasten to its normal stature all the more rapidly when markets regain their normal vitality. 19

True to this prediction, the plastics industry's production of 1931 surpassed that of 1929 only to drop to a low of 29,039,000 in 1932.[20] Economic conditions were responsible for this 12 per cent decrease in production over the previous year. However, when considered in comparison with all other industries, the record of plastics for 1932 may be considered very satisfactory.[21] Plastics also followed the general economic trend in the closing months of 1937 when plastics production fell off. This low production continued through 1938 until October when demands began to increase rapidly.[22]

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[19] "Plastics Use Moderate Decline to Plan Ahead," <u>Chemical and Metallurgical Engineering</u>, XXXVIII (January, 1931), 52.

[20] "Synthetic Resin Production," The Society of the Plastics Industry, Inc. 1950. Mimeographed.

[21] "Plastics Made Satisfactory Record," <u>Chemical and Metallurgical Engineering</u>, XL (January, 1933), 42.

[22] "Cellulose and Resin Plastics," <u>Chemical and Metallurgical Engineering</u>, XLVI (February, 1939), 114.

Overall Picture of the plastics industry during 1930's.--The plastics industry as a whole in the 1930's continued its expansion with hardly any commercial endeavor in which plastics failed to play a part. Extension of current applications and the finding of new uses for plastics were hampered somewhat because of the need for lower costs for plastic materials during this period.[23]

Plastics progress viewed at World Fairs.--The public became conscious that the plastics "trade" had grown into a full-scale industry by viewing the accomplishments of plastics in 1939 at the New York World's Fair and San Fancisco Treasure Island Exposition. Plastics at that time were being used in the manufacture of a wide variety of commercial products ranging from buttons to refrigerators.[24] Although the accomplishments of plastics were many, they had not as yet reached the period of their greatest success.

The Influence of World War II on the Growth and Expansion of the Plastics Industry

By 1940 the United States had taken a substantial lead

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[23] Philip H. Smith, "Plastics Come of Age," Scientific American, CLII (January, 1933), 5-7.

[24] Plastics Catalog, 1945, p. 10.

over the rest of the world in the manufacture of plastics.[25] Production at that time was devoted largely to civilian goods, but the year was also to find the plastics industry beginning the important role it played during the war by concentrating on the task of tailoring existing materials to military needs. Although many new materials were to appear during later war years, no new materials appeared on the market in 1940. Use of plastic plywood for wing and fuselage construction was begun and also use of plywood in construction of boats that were the predecessors of the famous PT boats.[26]

The twofold role of plastics in the war.--During the decade from 1931 to 1941, the output of plastics had increased from 50,000,000 to 500,000,000 pound which is the same as if production had doubled every five years.[27] In 1941 the plastics industry was still devoted largely to production for peacetime living by turning out millions of industrial parts which went into automobiles, radios, household appliances, and many other industrial products.

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[25] Felix N. Williams, "The Peak Is not Yet," Monsanto Magazine, XXVI (October, 1947), 2.

[26] Plastics Catalog, p. 12.

[27] Simonds and Sherman, Plastics Business, p. 283.

Injection presses were producing both small wares and intricately designed large pieces in quantities undreamed of five years previously at prices which were low, but profitable.[28] Then the war changed the outlook of the plastics industry when the Office of Production Management issued a request that plastics be substituted wherever possible for such strategically important metals as aluminum and magnesium. This was an excellent opportunity for plastics though at the time the request was issued, it was feared that a shortage of chemical raw products for plastics production might prevent the industry from taking full advantage of this opportunity.[29] Plastics began another important role in 1941 which was their use in manufacture of gas masks, airplanes, and a number of other articles for army and navy needs.[30]

Plastics in 1942 surpass record year of 1941.--All production records were broken by the plastics industry in 1941 and while the rate of change from peacetime to wartime

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[28] Modern Plastics, XXI (November, 1944), 97.

[29] H. M. Batters and J. A. Lee, "How Much Can Plastics Production Be Expanded," Chemical and Metallurgical Engineering, XLVIII (May, 1941), 128-131.

[30] "Plastics in 1941," Chemical and Metallurgical Engineering, XLVIII (February, 1941), 98.

applications was accelerated as the year progressed, 1942 found the industry still in the transitory stage. A survey early in 1942 revealed that the industry was operating at about 50 per cent of its potential maximum capacity and was in a position to double its output by doubling its work week. The first six months after the United States entered the war did not alter this situation to any great extent for the molding industry was in the process of re-tooling while many important contributions of plastics to the war were still in the blueprint stage. Before the year's end, the uses of plastics were limited almost entirely to military and essential civilian needs. As a whole, the plastics industry went ahead tremendously in 1942, and lower prices were brought about by the higher production during the year. Indicative of the trend in the entire plastics industry was the production rate of cellulose acetate which was 24,000,000 pounds during the first part of 1942 compared with 15,600,000 in a corresponding period in 1941.[31]

New trend forecast for plastics due to war influence.--The many new applications that the plastics undustry was learning during the war forecast a new trend for plastics after the war. The industry was built on a foundation of a large number of applications calling for comparatively

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[31] "Plastics," Chemical and Metallurgical Engineering, L (February, 1943), 108-109.

small amounts of plastics, and it was apparent that this stage in the life of the industry was coming to an end. The post-war period would bring about uses requiring large volumes of materials which would overshadow the small outlets adding greatly to the stature of the industry.[32]

Plastics set new production records in 1943-1944.--All plastics made progress of varying degrees in 1943. Increased demands for acrylic resins for aircraft parts and parts for use in ship-building made it necessary to enlarge manufacturing facilities of these materials. Manufacturers were not able to meet all military demands for cellulose acetates although production was as large as the War Production Board would allow.[33] War demands brought about a number of new plastics though many of these discoveries were kept in protective custody because of reasons of national security.[34] These new technical and engineering developments continued in 1944 with the aircraft industry continuing to lead as the foremost investigator of plastics for parts and accessories.[35] Synthetic resin production for 1944 was 784,137,000.[36]

[32] Ibid.

[33] "Plastics Materials," Chemical and Metallurgical Engineering, LI (February, 1944), 117.

[34] Plastics Catalog, 1945, p. 10.

[35] Ibid., p. 18.

[36] "Synthetic Resin Production," The Society of the Plastics Industry, Incorporate, 1950. Mimeographed.

Plastics reach their wartime peak and begin reconversion.--The beginning of 1945 found virtually no phase of war activity or essential industry untouched by plastics. There were now nearly twice as many main classes of plastics as there were in 1939.[37] Production reached 818,000,000 pounds which represents an increase of more than 540,000,000 pound over 1940.[38] With the end of the war in 1945, the plastics industry was looking ahead to reconversion for peacetime production for civilian uses. The effect of the war on the plastics industry was tremendous and is summarized in the following statement:

> At no period in the history of plastics have we experienced the technical progress that has been made during the past five years. With few exceptions, the plastics materials which were available in 1940, had been greatly improved by 1945. Many new plastics made their appearance which being of certain unique characteristics, have made possible the application of plastics in many items where formerly no suitable plastics were available.
>
> The introduction of high-frequency heating has greatly increased the output of the industry,especially in the field of larger moldings, with a definite improvement in quality. Better injection equipment, a greater 'know-how' by the industry as a whole, has resulted in general improvement in all plastic articles. 39

With servicemen returning as ten million users familiar with plastics, the plastics industry's outlook at the end of the

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[37] Plastics Catalog, 1945, p. 18.

[38] "Synthetic Resin Production," The Society of the Plastics Industry, Inc., 1950. Mimeographed.

[39] N. O. Broderson, Modern Plastics, XXIII (January, 1946), 94.

war was very bright. Although there were some predictions that the large output of plastics would not be maintained with the stimulus of war removed, the plastics industry was optimistic with many manufacturers planning to expand their production facilities.[40]

### The Post-War Plastics Industry

One of the most difficult problems facing the plastics industry following the war was the extensive misapplication of plastics. Many plastics were made into products for which they were unsuitable but because of the shortage of consumer goods, dealers filled their shelves with these items because they were available. Bad publicity for the plastics industry resulted from such misapplication. Competition has eliminated this practice, and each new product of the plastics industry is now tested for its particular application before being placed on today's competitive markets.[41]

*Continued expansion of the plastics industry in the post-war period*.--Instead of the predicted decline in plastics production after the war, an increased demand developed.

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[40] "Plastics and Rayon Prepare for Peacetime Progress," *Chemical and Metallurgical Engineering*, LIII (January, 1946), 106-107.

[41] Hiram McCann, "Doubling-Tripling-Expanding,That's Plastics," *Monsanto Magazine*,XXVI (October, 1947), 8.

Early in 1946 manufacturers had on order 1600 injection presses, a total almost equal to the number in operation at that time.[42] During the post-war development, many new firms opened in the plastics field.[43] Figures on plastics production have grown each year while sales had reached a billion dollars by 1949. The industry, while not yet fully grown, has taken a place of major importance in the national economy. There seems to be no saturation point for plastic materials in the immediate future.[44]

### The Present Size of the Plastics Industry

Today the plastics industry is larger than ever before in its history. The Society of the Plastics Industry estimates that the production of all plastics in 1950 will be more than 1,650,000,000 pounds which is phenomenal for an industry which in 1922 produced a total of only 5,944, 133 pounds. Production is more than twice the size it was at the end of the war.[45]

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[42] Ibid.

[43] H. R. Simonds, Plastics Business, p. 283.

[44] Society of the Plastics Industry, Inc., Plastics, the Story of An Industry, p. 7.

[45] U. S. Department of Commerce, Office of Domestic Commerce, "Plastic Materials," Chemicals and Drugs, pp. 45-46.

<u>Major divisions of the plastics industry</u>.--The modern plastics industry contains four separate and distinct types of operators employing around 100,000 persons. These four types include material suppliers, molders, fabricators, and laminators. The material suppliers are the producers of plastics and in most cases are large chemical manufacturing companies. There are approximately twenty-five material suppliers whose employees number appriximately 20,000 persons. The function of this group is to supply compounds in powder, granular, or flake form to molders of finished products and sheets, rods, tubes, films and foils to fabricators who work these into finished products.[46]

A second group is made up of molders and extruders who use molding compounds to mold finished products. Comprised of about six hundred and fifty operators, this group employs approximately 30,000 persons.[47]

A large employment opportunity is provided by the third division of the industry which consists of fabricators who machine finish or semi-finish products from rods, sheets, and tubes as well as special shapes. There are about 1500 firms in this field with the size of the plant ranging from one

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[46] Society of the Plastics Industry, Inc., <u>Plastics, the Story of an Industry</u>, p. 8.

[47] <u>Ibid</u>.

employing 300 persons down to a plant where the owner is the sole operator. Some of these plants have small investments and simple equipment for production of small novelties while others have costly and highly specialized equipment and produce novelties or complex industrial items in large quantities. Fabricators use many tons of plastic materials each year.[48]

Laminators make up the fourth group. Using liquid resin, this group impregnates paper, cloth, or wood and treat glass fibres which they form into composite sheets, rods, or tubes and fabricate into final form.[49] About thirty companies are engaged in laminating.[50] Though the plastics industry may be small in comparison with such industries as steel, it may be roughly estimated that one out of every five hundred gainfully employed in the United States works in plastics.[51]

## The Future of Plastics

In considering the future of the young plastics industry, one may wonder what extremes it may some day attain. It has grown so rapidly that almost any prediction made has some possibility of accomplishment. The work toward discovery of

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[48] Ibid.

[49] Ibid., p. 9.

[50] Simonds, Plastics Business, p. 9.

[51] Clark N. Robinson, op. cit., pp. 138-139.

new products and new applications continues unceasingly in the chemical laboratories of such large firms as E. I. Du Pont de Nemours, Celanese Corporation, Bakelite Corporation, and Dow Chemical. To what heights such research will the industry, no one can sagely predict.

Remote future of plastics.--In the remote future of plastics we find such possibilities as the all-plastic house. That plastics may some day replace wood in construction of houses does not seem possible at this time. When it is realized that while the furnace and wiring are the only two parts of a house that cannot be made of plastics, an ordinary $6,500 house made of wood would cost $100,000 when made of plastics.[52] A similar situation to this exists in the possibility of an all-plastic automobile. The following statement summarizes plastics' limitations in this field:

> 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 stand point 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 designed throughout to take advantage of the new material.[53]

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[52] General Electric Corporation, What Are Plastics?, p. 1.

[53] William B. Stout, "The Automotive Industry--What It Needs from the Plastics Industry," Modern Plastics, XXIII (January, 1946), 107.

The all-plastic house and the all-plastic automobile are still in the future, and many in the plastics industry are willing to leave them there as possibilities for future research.[54]

The near future of plastics.--The discovery of new materials is not progressing today at the rate that it did in the past for the industry is now devoting more time to new applications for existing materials. Plastics in the future will be worked more frequently with wood, glass, and metals. Hyphenated names of materials such as resin-wood, resin-paper, or resin-cloth will be heard as combinations of these new materials are developed.[55]

Employment opportunities in plastics.--The continued growth of the industry is expected to create jobs for a number of persons in the plastics field. Although the better-paying jobs will go to those persons having mechanical or engineering training, many openings will be available to those persons who have grammar or high school training. The plastics industry employs a number of persons who have gone no farther in school than this and offers them the opportunity for better paying jobs by taking courses given by

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[54] James R. Turnbull, "In the Plastics Future," Monsanto Magazine, XXVI (October, 1947), 38.

[55] Ibid.

trade or vocational schools and supplementing this instruction by reading books and other materials about plastics.[56]

Summary.--The trend in the plastics industry is for continued growth. Greater volume output is expected in the future as material producers, molders, fabricators, and distributors through wider cooperation develop sound promotion and merchandising policies.[57] The outlook will continue to be good for the plastics industry for the industry is one in which raw materials have never quite caught up with the demand for plastic products.[58]

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[56] Society of the Plastics Industry, Inc., Plastics, the Story of an Industry, p. 29.

[57] U.S. Department of Commerce, Office of Domestic Commerce, "Plastic Materials," Chemicals and Drugs, pp. 45-46.

[58] Felix N. Williams, op. cit., p. 1.

# CHAPTER III

## THE USES OF PLASTICS

Since the forming of the first celluloid denture in 1870, uses of plastics have expanded until now many thousands of products are made entirely or in part of plastics. Many useful consumer goods on the market today could not have been made with any material other than plastics. Because of modern production methods developed in industry, molded products the size of a comb can be produced at the rate of thirty-two per minute by one machine.[1] A product the size of a one-piece console television set cabinet made of plastics can be produced at the rate of 160 per eight-hour day by one machine at a greatly reduced cost over wooden cabinets.[2] These are but two examples of the many ways in which plastics are used. Almost every major industry uses plastic materials or products in some form. Some of these manufacturing fields in which plastics are used are listed below.[3]

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[1] F. A. Abbiati, "The Horn of Plenty Is Mechanized," _Monsanto Magazine_, XXVI (October, 1947), 26.

[2] "Admiral Cabinets Make History," Modern Plastics, (January, 1950), 153.

[3] _1950 Modern Plastics Encyclopedia and Engineer's Handbook_, pp. 1012-1018.

Aircraft
Arts and crafts
Automotive
Bearings
Boat construction
Brake linings
Building
Chemical plant equipment
Displays
Electrical
Electroplating equipment
Flooring
Footwear
Furniture
Hardware
Housewares
Housings for machines
Inks
Jewelry, novelties
Lighting
Luggage
Luminescent products
Medical
Models
Motion pictures
Musical Instruments
Optical products
Packaging
Photography
Plumbing
Printing
Radio and television
Recordings
Refrigerators
Signs
Sporting goods
Telephones
Toys
Upholstery

The above list is not intended as a complete listing of all the uses of plastics but is given to illustrate the wide range that these uses cover.

## Uses of Plastics in Industry

Modern industry has thousands of uses for plastics and each of these uses represents a different processing problem for the plastics manufacturer who determines plastic materials suitable for each application. These materials are then furnished to the industrial user of plastics in the form of molding powder. This powder may then be processed by one of two methods. In the first of these methods, molding powder is subjected to heat and pressure and is used for making laminates, resin glues, coating materials, and numerous other products. The second processing method utilizes molding powder to make liquid resins which are then poured into open molds and oven-baked until the resin hardens. These cast resins are then supplied to fabricators who work them into various products. Fabricated forms furnished to manufacturers also include plastic sheets, sheeting and film, tubes and tubing, and rods which have many applications.[4]

While many industries have begun using plastics only during the past two decades, there are several industries which made much earlier uses of plastics. Major industries that have used plastics for a number of years are the electrical, chemical, and automotive industries.

Plastics in the electrical industry.--Phenol-formaldehyde which was developed in 1909 by Baekeland was to find quick acceptance in the electrical industry as a superior material to porcelain, hard rubber, and shallac compositions which were used as earlier types of insulation. Emile Hemming using phenol-formaldehyde did pioneer work in developing a commercial, heat-resisting, molded product for wiring devices and electrical insulation.[5] Most of the plastic moldings produced prior to 1920 were produced by General Electric, Westinghouse, and Continental-Diamond Fibre for their own consumption as electrical insulation.[6]

The modern electrical industry continues to use phenol-formaldehyde as well as newer materials such as vinyls,

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[4]Bakelite Corporation,"How Industry Adapts Plastics to Its Needs," The ABC's of Modern Plastics, pp. 15-25.

[5]Emile Hemming, Plastics and Molded Electrical Insulation, pp. 175-181.

[6]Simonds, Weith, and Bigelow, Handbook of Plastics, p. 1.

polyethylene, and nylon. Plastics are used in the electrical industry for tube bases, fixed condensers, dial knobs, coil forms, insulators, plugs, meter housings, electrical wall-plates, and switches.[7] Plastic insulation protects wire from acids or alkaline soils, severe weather, oil, grease, oxidation, and abrasive wear. Another advantage of plastic insulation is that colored pigments may be added to the outer covering of the wire, thus aiding in quick identification of wires.[8]

Uses of plastics in the chemical industry.--Another industry to find early uses for plastics soon after their discovery was the chemical industry. Chemical plants have a need for materials which will withstand water, oil, fumes, heat, and solvents that are present, therefore plastics were materials for equipping these plants. During the 1920's the chemical industry began equipping plants with plastic materials because of their superiority to wood and metals which were formerly used. Cellulose nitrate and cellulose acetate were put to use where rollers were subjected to weak acids, as linings for circulating pipes and tanks, as coatings to provide smooth, washable working surfaces, and as coatings for dipping paddles. Phenol-formaldehyde

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[7] Ibid., p. 812.

[8] Bakelite Corporation, Vinylite, Resins and Plastics, p. 25.

tumbling barrels were built to be used for the plating of copper and nickel. These plastic tumbling barrels far outlasted the wooden barrels which they replaced. Further uses were as coating for corrodible metals, and laminates were used to replace metal gears which were subjected to the splashing of acids.[9] These plastics are still used for equipping chemical plants up to the present while newer plastics are also finding uses in the chemical industry. A recently developed plastic which is being used by the chemical industry is tetrafluoroethylene with the trade name, "Teflon," which is used for pump and valve packings and outlasts other materials up to 300 times, thus greatly reducing replacement and maintenance costs.[10]

Plastics in the automotive industry.--An industry which began the use of plastics shortly after the start of the twentieth century is the automotive industry. The first plastic used in the automotive industry was the celluloid front storm curtain on the 1905 Olds, while other early uses included phenolic resin in the first electric starter in 1911 and in distributors and distributor heads in 1913. By 1918 phenolics had additional uses in gear shift knobs, handles,

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[9] "Plastics Play Promising Part in Equipping Modern Plant," Chemical and Metallurgical Engineering, XXXVI (September, 1929), 569-571.

[10] E. I. DuPont de Nemours, Inc., DuPont Plastics, p. 8.

and gas tank caps. Plastic steering wheels were the largest single application generally adopted by the automobile industry.[11]

A problem that had faced the automobile industry for a number of years was flying glass which caused disfiguring injuries in accidents. This problem was solved by using plastics combined with glass. The following statement published in 1928 explains some of the problems encountered during the research to develop what was later to be known as "safety glass."

> The field is being actively investigated with the hope that a substance can be found which can be cheaply produced and will serve to bind firmly together two sheets of glass to afford a non-splintering quality which nitrocellulose provides. At the present time cost of such a 'sandwich' glass is so great that it is not used widely in automobiles, but if producible at a reasonable cost the market would be a very wide one as it should supersede ordinary plate glass in automobiles and the consumption in this direction alone would be enormous. [12]

These early experiments with cellulose nitrate produced a safety glass which was successful in preventing glass splintering but would crack and turn yellow with age. Cellulose nitrate has now been replaced with vinyl butyral for safety glass and provides protection while remaining clear.[13]

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[11] Modern Plastics, XXVII (January, 1950), 156.

[12] Carlton Ellis, "Less Familiar Aspects of the Plastics Industry," Chemical and Metallurgical Engineering, XXXV (January, 1928), 19.

[13] N. N. T. Samaras, "Something Nature Could not Supply," Monsanto Magazine, XXVI (October, 1947), 23.

Paralleling the growth of the automobile industry itself is the increased use of plastics in automobiles. During 1941 prior to World War II, 3,800,000 cars were produced in which an average of seven and one-half pounds of plastics were used. Plastics were used in even greater quantities during the post war expansion of the industry until in 1949 an average of fourteen pounds were used in each of the 5,000,000 cars produced. The recent trend in automobiles is to use acrylic in hood ornaments, front and rear deck nameplates and medallions, stop light lenses, tail lights, parking lights, and license lights. Another recent improvement using plastics is the development of rivetless brake linings bonded with phenolic.[14]

The increasing use of plastics by industry.--Many industries which have used plastics to some extent for several years are now developing many additional uses for plastic each year. Refrigerator manufacturers compose one group who have increased their use of plastics in recent years. This increased use of plastics is due to their lightweight, ease of cleaning, decorative appearance, strength, resistance to cold, humidity, and food acids. One refrigerator manufacturer who had used no plastics in pre-war refrigerators was using 2,000,000 pounds by 1947. During the year 1947 the

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[14] Modern Plastics, XXVII (January, 1950), 156.

the refrigerator industry as a whole used 25,000,000 pounds of plastics.[15] By 1949 this total of plastics used for refrigerators had increased to 80,000,000 pounds. This use of plastics in the building of refrigerators has resulted in more storage space, lower operating costs, longer life, and less maintenance.[16]

Manufacturers of other household appliances are also major users of plastics. Radios, vacuum cleaners, and washing machines are some of the products which use a number of plastic parts in their construction. While once all radio cabinets were made of wood, 10,000,000 pounds of plastics are now used annually for the manufacture of radio cabinets and radio parts.[17] Plastics are also being used extensively in the rapidly expanding television industry.[18] The manufacture of washing machines uses 2,000,000 pounds of plastics each year; 4,500,000 pounds are used for vacuum cleaners; 5,000,000 pounds are used for electric iron handles; and

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[15] Hiram McCann, "Doubling-Tripling-Expanding, That's Plastics," Monsanto Magazine, XXVI (October, 1947), 5.

[16] Modern Plastics, XXVII (January, 1950), 107.

[17] Hiram McCann, op. cit., p. 5.

[18] "Philco's Approach to Plastics," Modern Plastics, XXVII (January, 1950), 151.

10,000,000 pounds of plastics are used in the manufacture of smaller electrical appliances such as clocks, while 500,000 pounds are used for the manufacture of stoves. A total of 57,000,000 pounds of plastics is used annually for the manufacture of household appliances.[19]

Applications of plastic adhesives.--The use of plastic adhesives has grown steadily in recent years and has solved many manufacturers' bonding problems such as the joining together of unlike materials. With plastic adhesives wood can be bonded to aluminum, copper, steel, or other metals and the result is a bond stronger than the wood itself. Both thermosetting and thermoplastic type of plastics are used for making plastic adhesives though each type has its particular applications. Thermoplastic bonding may be used only where it will not be affected by heat, whereas thermosetting adhesives must be used when the bonding is subjected to higher temperatures.[20] By using plastic adhesives in the manufacture of plywood, the applications of plywood have been greatly extended. Limited for years to inside uses because of the fact that it cracked, buckled, and fell apart when exposed to weather, these problems were overcome with the introduction of thermosetting plastic adhesives, and now plastic

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[19] Hiram McCann, op. cit., p. 5.

[20] Robinson, Meet the Plastics, pp. 55-60.

plywood has many exterior uses. A drawback to more extensive use of plastic bonded plywood is that its price is higher than plywood made with ordinary glue. Plastic bonded plywood is used in aircraft construction, prefabricated houses, furniture, and was used for the hulls of the famous PT boats in World War II.[21]

Miscellaneous items made of plastics.--Plastics are used in the manufacture of many small articles. Twenty to forty million pounds of plastics are used annually for the manufacture of buttons. Forty per cent of all toys are made of plastics, and many millions of pounds are used annually for the manufacture of small items such as combs, brushes, fountain pens, tableware, toothbrushes, and many other articles.[22]

Why industry uses plastics.--The widespread use of plastics in industry is due to the wide range of physical qualities possessed by the many different kinds of plastics. They range in color from white to black and may be translucent, opaque, or transparent; some are rigid; others are flexible, while others have elastic qualities. Plastics are resistant to moisture, corrosion, and moderate heat. Some

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[21] Ibid., pp. 60-64.

[22] Hiram McCann, op. cit., p. 5.

provide excellent insulation to electricity and heat, and all plastics are comparatively light in weight.[23] This versatility of plastic materials is responsible for industry's choice of plastics for so many manufacturing applications.

## Architectural Uses of Plastics

The use of plastics in architecture is in its infancy. Through use of plastic bonded plywood, plastic wall and floor tile, plastic decorative illumination fixtures, and plastic finishing materials, the trend for more architectural applications of plastics is increasing.

Architectural applications for laminates and plywood.--Resin bonded plywoods and laminates are two materials which provide beauty with water and wear resistance. The materials are being used in hotels, restaurants, office, libraries, theaters, hospitals, stores, and banks.[24] Plywood is being used for interior wall panels and for doors. An advantage of using plywood doors is that they do not warp with seasonal changes in temperature and humidity. Plastic laminates were first used extensively in many of the pre-fabricated houses that were built following World War II. Of the number of combinations of materials for laminates for pre-fabricated

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[23] Robinson, op. cit., pp. 1-2.

[24] Simonds, Weith, and Bigelow, op. cit., p. 1116.

housing materials, the plastics-and-paper-to-aluminum sandwich laminate is considered the best material developed for wall and ceiling construction.[25] Phenolic and urea laminates are the two types of laminates most widely used for architectural applications include wall surfaces, showers and bathrooms, telephone booths, and swinging doors in public buildings.[26]

Use of acrylics in architecture.--For decorative as well structural applications in architecture, acrylic plastics are the best available material. Large sheets of acrylic may be used for a variety of applications and may be either transparent or translucent, clear or colored, straight or corrugated.[27] The advantages of using acrylics in architecture are that they will not deteriorate with age or severe use, weigh half as much as glass, are virtually unbreakable, and can be heated to a pliable state and shaped to any curve or contour. Acrylics are used for partitions, coverings, doors, balustrades or other applications where glasslike sheet

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[25] 1950 Modern Plastics Encyclopedia and Engineer's Handbook, p. 975.

[26] Simonds, Weith, and Bigelow, op. cit., p. 1116.

[27] Modern Plastics Encyclopedia, 1949, p. 36.

material is desired.[28] Acrylic in rod form is also excellent for use as parts of balustrades and partitions.[29]

Use of Polystyrene for wall tile.-- Polystyrene wall tile is another plastic product that is becoming popular for architectural use. Plastic wall tile first appeared on the market in many shapes and sizes, but now standards have been set up by the Plastic Wall Tile Manufacturers Association to simplify marketing problems and to stabilize quality. Polystyrene wall tile is now available in two types. The difference between the two is that for one type the edges of adjacent tiles interlock while for the second type the edges are bonded with a mastic adhesive.[30] These wall tiles are used chiefly in kitchens and bathrooms.

Plastic flooring materials.--For plastic flooring materials, vinyls are the most suitable plastic material. Vinyl flooring is made either in the form of tile or as a solid sheet of floor covering. Plastic floor coverings offer the advantages of being resistant to household acids, resistant to dents and scuffs, wear and abrasion resistant,

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[28] Rohm and Haas Company, Plexiglas for Store Modernization, p. 1.

[29] Ibid., p. 4.

[30] Modern Plastics Encyclopedia 1949, p. 38.

and are made in a wide range of colors and patterns.[31] Vinyl plastic floor outwears ordinary floor coverings such as rubber tile, linoleum, and asphalt tile. Plastic flooring materials are particularly adaptable in the kitchen because of their wear resistance and ease of cleaning since dust and dirt will not adhere to its smooth, non-porous surface.[32]

Plastics used for decorative illumination.--Because of their excellent light transmission qualities, plastics are being used for a number of types of decorative illumination applications, particularly fluorescent lamps. Plastic materials can be tinted, embossed or louvered for different lighting effects.[33] Large plastic fixtures for home, office, and industrial use are economical to ship, handle, and install because of their light weight and resistance to breakage. Acrylics have opened new fields for use of plastics in decorative illumination because of their ability to pipe light. This feature is of great value for novel effects in signs and displays.[34] In the field of signs for

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[31] Ibid., p. 40.

[32] Bakelite Corporation, Vinylite Resins and Plastics, p. 23.

[33] Simonds, Weith, and Bigelow, op. cit., p. 1116.

[34] Modern Plastics Encyclopedia 1949, p. 53.

advertising purposes, acrylic signs are threatening the monopoly held by neon for a number of years. This new type of sign consists of acrylic face sheets decorated or lettered on their inside surfaces and illuminated from inside by fluorescent lamps. Initial cost for this type of sign is lower than neon signs and maintenance is practically eliminated since fluorescent tubes can be easily replaced.[35] Acrylic materials are also being used in skylights and as luminous ceilings with incandescent or fluorescent lights mounted above the translucent acrylic panels to provide an excellent light diffusing medium.[36]

Plastics' role in architectural finishing materials.--Finishing materials such as varnish and enamel have for a number of years contained plastic resins. Lacquers containing cellulose nitrate have been in use for over fifty years. Phenolic resins and alkyd resins have been used for a number of years for the manufacture of paints and varnishes. Though synthetic resins have been used more extensively in recent years, advertisements stating that a product is a "plastic paint" are misleading because of the fact that the plastics used are but a few of the many ingredients used to make up today's many types of finishing products. Reputable paint

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[35] "Acrylic Signs Threaten Neon," Modern Plastics, XXVII (January, 1950), 145-146.

[36] Rohm and Haas Company, op. cit., pp. 7-8.

manufacturers have tried to discourage this practice of misleading advertising and sell paint on its overall merits rather than emphasize the fact that the paint contains plastic ingredients.[37]

_The future of plastics in the architectural field._--The extravagant predictions made regarding extensive use of plastics in architectural applications in the future, including all-plastic houses and all-plastic furntiture can be realized only when the use of plastics is as economical as the use of woods and other present-day building materials. In the meantime plastic materials can continue to serve for many architectural applications for which they are best suited. Extended use of plastics in building is currently hampered because of restrictions in local building codes and the construction industry's conservative acceptance of the use of plastic materials. When these two problems have been overcome, plastics for architectural applications can be mass produced and the cost of these materials can be reduced to compete with other building materials.[38]

## Use of Plastics by the Individual Consumer

The plastic products which are manufactured are finding ready acceptance by the individual consumer. Proof of this

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[37] Robinson, _op. cit._, pp. 67-70.

[38] _Modern Plastics Encyclopedia 1949_, p. 33.

is the fact that more plastic products are being used in the home each year, indicating that these products are giving satisfactory service. The extent to which plastics have become a part of our daily lives is illustrated by the following statement:

> This is a plastic age. Our plastic day begins when the urea-formaldehyde alarm clock awakens us. In the bathroom our toothbrush has a cellulose acetate handle and we comb our hair with a polyamide. The shower curtain is polyvinyl. The breakfast table top is phenol-formaldehyde laminate. The morning weather report comes over a radio housed in a styrene case. The handle of the coffee pot is quite cool since it has a lignin handle. So we start our day by putting on a Koroseal raincoat and raising an umbrella with a Plexiglas handle. The ladies have no reason to be concerned about their nylons being splashed since they are also plastic. So as we go through the day we are in constant touch with some form of plastic. Even the synthetic automobile tires on which we ride are a type of plastic. 39

The above-mentioned uses are but a few examples of the many ways plastics have invaded modern living to our advantage.

Types of plastic materials used by the individual consumer.--Plastics have in recent years entered the home both as a decorative element and as the material from which a number of essential household items are made. Several examples are given in Table 2 for each of the types of plastics most frequently used for the manufacture of household products.

Perhaps the most familiar plastic article in the Table is the telephone. The first telephone set containing plastic

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[39] Coleman Hewitt, "Plastics in the Schools," Chicago Schools Journal, XXIX (January, 1948), 53.

parts was produced in 1925, and the evolution in telephone design since that time has been based on the increased use of plastics in telephone handsets. Present-day telephones were designed with the purpose of using plastics to the greatest extent possible. Each year four million pounds of plastics are used to produce new telephone handsets.[40]

TABLE 2

FOURTEEN TYPES OF PLASTICS AND TYPICAL PRODUCTS OF EACH USED BY THE INDIVIDUAL CONSUMER[41]

| Types of plastics | Uses |
|---|---|
| Acrylic | Hairbrushes, combs, salad bowls, lamps |
| Cast phenolics | Cutlery handles, pen desk set bases |
| Cellulose acetate butyrate | Lawn mower rollers, high chair trays |
| Cellulose propinate | Fountain pens, telephone housings |
| Ethyl cellulose | Tool handles, flashlight cases |
| Cellulose nitrate | Optical frames, fountain pens |
| Melamines | Wiring devices, kitchen utensils |
| Ureas | Tableware, buttons |
| Molded phenolics | Iron handles, radio cabinets, switches |
| Nylon | Brush bristles, fishing lines |
| Polyethylene | Frozen food wrap, raincoats, bottles |
| Polystyrene | Refrigerator boxes, wall tile, toys |
| Vinyls | Upholstery, flooring, phonograph records |
| Cellulose acetate | Toys, lampshades |

Use of Plastics in kitchen and bathroom.--The two rooms in the home where plastics are used to the greatest extent are the kitchen and the bathroom. In the kitchen plastics are

[40] "Four Million Pounds a Year," Modern Plastics, XXVII (January, 1950), 114-116.

[41] Plastic Materials Manufacturers Association, How to Buy and Sell Plastics, pp. 13-31.

used in tablecloths, refrigerators, refrigerator trays, handles for kitchen utensils, ice box dishes, tableware, including plates, cups, saucers, and handles for cutlery, and for utensils such as strainers and graters. Shelves may be lined with plastic sheeting, and floors may be covered with plastic coated linoleum, vinyl flooring, or plastic floor tile.[42] Laminates have become standard equipment in kitchen working surfaces such as tops for kitchen cabinets and table tops.[43]

The bathroom in the modern home may feature a plastic shower head, plastic faucets, a plastic shower curtain, plastic towel racks, and a plastic toilet seat. The wall tile may be made of plastics with plastic electrical outlets into which may be plugged an electric shaver with a plastic case. Toothbrush handles, bath brush handles, toothbrush tubes and caps, combs, and hairbrushes are other bathroom accessories that are made of plastics.[44]

Plastics for drapes, upholstery, and floor coverings.--Throughout the other rooms in the house, plastics are featured in many other roles such as washable wallpaper, draperies made entirely of plastics, or textile drapes may be treated

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[42] Charles Sweeney, "The World That Plastics Built," *Monsanto Magazine*, XXVI (October, 1947), 9.

[43] *Modern Plastics*, XXVII (January, 1950), 126.

[44] *Ibid*.

with plastic materials to make them stain resistant. Plastic sheeting is now being used as upholstery materials for living room furniture and has the advantages over other upholstery materials of being washable, wear-resistant, and fadeproof.[45] A recent development in floor covering is vinyl carpeting which is designed to be used where it will receive hard wear. Plastic coated fabric combined with sponge rubber gives an easy to clean, wear-resisting flooring with a carpet-like feel.[46]

Laminates for home furniture.--Much of the furniture used in the home today is being made of laminates. Many horizontal and vertical surfaces that are subjected to hard wear and scuffing including such items of furniture as occasional tables, dinette tables, dressing table tops, and many others. Laminates are finding acceptance by the consumer because they give far better service than the quick-drying lacquer finishes formerly used almost exclusively by furniture manufacturers. The laminates used for furniture are composed of 1/85 inch thickness of actual wood, plastic impregnated paper, and a sheet of aluminum foil. This combination of materials is bonded together by means of heat and pressure forming a 1/16 inch thickness of laminate which is impervious to alcohol,

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[45]Charles Sweeney, *op. cit.*, p. 11.

[46]B. F.Goodrich Chemical Company, *Geon Polyvinyl Materials*, p. 10.

acetone, carbon tetrachloride, fruit juices, hot water and lighted cigarettes. Since lacquer finishes cannot supply protection comparable to laminates, it can be expected that laminated furniture will find wider acceptance in the future to eliminate the costly refinishing necessary on surfaces which can be ruined by spilled liquids or lighted cigarettes.[47]

Miscellaneous plastic products used by the individual.--Miscellaneous plastic products used by the individual are numerous. Flashlight cases, cameras, clocks, smoking stands, fluorescent fixtures, vacuum sweepers, door knobs, lamp bases and shades, luggage, and eye glass frames are some of the ways in which the individual consumer uses plastics. Other uses include fishing lines, fishing rods, clothes, clothes, hangers, tennis rackets, handbags, belts, mattress covers, and baby carriage covers. An important way in which plastics serve the consumer is in providing sanitary wrappings for foods. Milk is now being sold in leak-proof paper containers impregnated with plastic adhesives. Children's toys are made of plastic and offer the advantages of being non-toxic and washable.[48]

Consumer Education for buying plastic products.--The many uses of plastics that have been cited are proof of the great

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[47] J. Graham, "For Furniture with a Future," Plastics Newsfront, IX (April, 1949), 11.

[48] Bakelite Corporation, A Simplified Guide to Bakelite and Vinylite Resins, pp. 2-23.

influence of plastics on daily living. Many of the uses of plastics are now so old that they no longer attract attention while the new plastic products placed on the market are virtually assured sale based on the past performance of other plastics. Plastics in general have a good reputation and the consumer has a good attitude toward plastic products. However, the plastics industry is aware that public popularity is a fickle thing and is striving to increase the consumer's knowledge of plastics through informative labeling, advertising, and other means to educate the consumer so that he may exercise judgment in the selection of plastic products. The Society of the Plastics Industry, the Society of Plastics Engineers, and Plastic Materials Manufacturers Association sponsor exhibits to familiarize the public with the usefulness of plastic products.[49] Schools can do much to educate students regarding plastics. Through units of study on plastics, work with plastics in shop courses, and study of plastics in chemistry classes, the generation of students now in school can become a well informed buying public in regard to plastics.

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[49] Clark N. Robinson, *op. cit.*, pp. 150-153.

# CHAPTER IV

## THE NEED FOR ADAPTATION OF WORK WITH PLASTICS AS A PHASE OF INDUSTRIAL ARTS WITH SPECIAL REFERENCE TO THE OBJECTIVES OF GENERAL EDUCATION AND INDUSTRIAL ARTS

With the increasing use of plastics products in daily living and the widespread use of plastics as an industrial material, it became apparent that the school must include study and use of plastics as a part of its program to keep abreast of current developments. The indications are that plastics will play an even greater role in our lives in the future, for the plastics industry is very young and is still expanding. Because the plastics industry has grown into prominence only in recent years the buying public today does not have the years of consumer experience necessary for wise selection in the purchase of plastic products. Thus the need is created for the school to provide its students with the opportunity to study and work with plastics so they may learn the advantages and also the limitations of these materials. The better knowledge of plastics that will result will provide students with the necessary basis for selection of plastic products which will best suit their needs.

## The Need for Study of Plastics in Fulfilling The Needs of Youth

Whether or not the student will benefit must be the criterion used to determine if studying and working with plastics is to become a part of the educational program of schools. Consideration must be given to how the study of plastics will help to achieve the objectives of general education and help toward meeting the needs of youth. General education objectives today should be based on the ten imperative needs of youth which were determined by the American Youth Commission. These ten needs of youth are listed below:

1. All youth need to develop saleable skills and those understandings and attitudes that make the worker an intelligent and productive participant in economic life. To this end, most youth need supervised work experience as well as education in the skills and knowledge of their occupations.
2. All youth need to develop and maintain good health and physical fitness.
3. All youth need to understand the rights and duties of the citizen in the democratic society, and to be diligent and competent in the performance of their obligations as members of their community and citizens of the state and nation.
4. All youth need to understand the significance of the family for the individual and society and the conditions conductive to successful family life.
5. All youth need to know how to purchase and use goods and services intelligently understanding both the values received by the consumer and the economic consequences of their acts.
6. All youth need to understand the methods of science, the influence of science on human life, and the main scientific facts concerning the nature of the world and of man.
7. All youth need opportunities to develop their capacities to appreciate beauty in literature, art, music and nature.

> 8. All youth need to be able to use their leisure time well and to budget it wisely, balancing activities that yield satisfactions to the individual with those that are socially useful.
> 9. All youth need to develop respect for other persons, to grow in their insight into ethical values and principles, and to be able to live and work co-operatively with others.
> 10. All youth need to grow in their ability to think rationally, to express their thoughts clearly, and to read and listen with understanding.[1]

Study and work with plastics can make a direct contribution toward fulfilling many of the above listed needs. A review of these imperative needs of youth to determine those to which work with plastics can make a contribution will reveal that skills in the use of both machine and hand tools can be developed by the student when he works with plastics in school shop courses. The opportunity is also offered for supervised work experience, and those students who develop interest and show aptitude for working with plastics may be provided with the knowledge necessary for the foundation of a lifetime occupation. A study of the many different kinds of plastics and the applications of each will aid the student to make wiser selections in buying the many plastic articles offered for sale on the market today.

No other material offers a better opportunity than plastics to help the student understand the methods of science

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[1] Paul E. Elicker, "The Needs of Youth," <u>School Executive</u>, XLVII (February, 1948), 48-49.

and the contribution that science is making to our daily living. Since plastics are the product of the chemical laboratory, study of the composition of the different types of plastics, their current uses, and the need for further research in development of new uses will aid the student in a better understanding of the methods of science.

Constructive use of leisure time may result from using plastics as a material for a handicraft hobby. Handicraft using plastic materials provides the opportunity to have a hobby which anyone can practice and may produce either large or small projects with a small investment in tools and equipment. In addition to the needs mentioned above to which study and work with plastics can make a direct contribution toward fulfilling, indirect contributions toward fulfilling the other needs of youth may be gained by working with plastics.

### A Proposal for the Adaptation of Work with Plastics as a Phase of Industrial Arts

While it has been pointed out that plastics can be of value in meeting the needs of youth on which the objectives of general education are based, this study is concerned specifically with how work with plastics will benefit the student of industrial arts and will contribute to the accomplishment of the objectives of industrial arts. A statement as to what the objectives of industrial arts are and as to whether plastics as a part of industrial arts is in keeping with these objectives is given on the next page.

> There may be indecision on the part of some school people regarding the advisability of including instruction in such materials as plastics in the school shop course of study. However, if the objectives of the industrial arts program are reviewed, one can readily see that in order to explore industry no industrial arts course would be complete without a study of plastics. To quote one statement of objectives of industrial arts education, we find that such training should 'develop in the student a knowledge and appreciation of industry and industrial life; provide experiences which can be used by the student in leisure time and avocational pursuits; develop the student's ability to select wisely, buy intelligently, and properly care for the industrial products he buys and uses; and develop the student's ability to express himself creatively, using the tools and materials of industry.' These are only a few of the objectives of a functioning industrial arts program, but they are objectives which can be obtained very satisfactorily, in part at least, through a study of the comparatively new material of industry--modern plastics. 2

In keeping with these objectives of the industrial arts program noted above, plastics provide an excellent material for use as a leisure time handicraft material. Study of the different kinds of plastics and the applications of each will provide the student with the background necessary to buy wisely from the large variety of plastics products offered for sale to the consumer today. When the student of industrial arts works with plastics, he has the opportunity to create designs of his own because of the many possibilities in the use of plastics, and he may learn skills in the use of both hand and machine tools of industry.

Increased importance of the plastics industry and the use of plastics as an industrial arts material.--The plastics

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[2]Donald B. Greenwood, "Plastics in the Industrial Arts Shops," Industrial Arts and Vocational Education, XXXVIII (October and November, 1949), 316-317.

industry with its phenomenal growth of about 2,000 per cent since the beginning of the twentieth century is an excellent example to use in teaching industrial arts students of the materials and processes of industry.[3] As one of our youngest industries which has expanded rapidly in recent years, the plastics industry is an outstanding example to use in teaching the growth of industry in the United States. The plastics industry has in the past twenty-eight years increased its production from 5,900,000 pounds in 1922 to an estimated production of 1,650,000,000 pounds in 1950.[4] A statement in regard to the value that plastics can be to the industrial arts program is as follows:

> In the industrial arts field no other material lends itself more to the study of industry and its production [than plastics]. It is new and ever-changing and its use in our modern life has expanded our concept of material beauty, durability and ease of production. . . . . . . . . . . . . . . . . . . . . . . . . The industrial arts plastics course, if properly taught, will acquaint the student with these many applications of this important industrial material and will result in giving our growing American population a greater understanding and appreciation of the world in which we live.[5]

Plastics are easily adapted to the majority of industrial arts shops and require very little extra effort on the part

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[3] Ibid.

[4] "Synthetic Resin Production," The Society of the Plastics Industry, Inc., 1950. Mimeographed.

[5] Donald B. Greenwood, op. cit., p. 317.

of the teacher to use it as a handicrafts material. Plastics will act as a means of creating new interest in industrial arts classes and can be worked without addition of more costly equipment.[6]

Availability of plastic materials.--Manufacture of plastics in large quantities has made these materials available to those who use them for handicraft.[7] The unavailability of plastics for this purpose was a problem facing many teachers and hobbyists who wanted to use plastics during the earlier days of the industry. While most manufacturers do not solicit retail business from plastics handicraft workers,it is now as easy to purchase a small amount of plastics from handicraft stores as it is to purchase any other crafts material.[8]

The shortage of wood may hasten the use of plastics as an industrial arts material.--In addition to its other values to the industrial arts program, plastics may be used as an industrial arts material in place of wood which is in shortage at the present time. Although metal has developed to a place of equal importance in recent years, wood has been for many years the chief material used in industrial arts. Today

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[6] Ibid.

[7] Mansperger and Pepper, Plastics, Problems and Processes, p. v.

[8] Andrew J. Lockrey, Plastics in the School and Home Workshop, p. vii.

the shortage of wood that faces the United States as a whole is also having its effect in the industrial arts shops. Wood that may be purchased today is of inferior quality and in many cases may be unusable because of excessive warpage. No hope of relief from the wood shortage can be expected if we are to believe the following prediction:

> Lyle F.Watts, Chief of the Forst Service, United States Department of Agriculture, Washington, D. C., predicts that the present shortage of timber products will last for years to come. In the past 36 years the nation's woodpile has been reduced by more than 40 per cent. The total stand of saw timber in the United States has been estimated at 2826 billion board feet in 1909 and is being shown by a nationwide forest service study to be 1601 billion board feet at the present time. (1947). 9

This forest depletion is in evidence throughout the entire country. Timber supply needs in the future can be met only by re-planting areas where the timber has been chopped down.[10]

To solve the problem of a supply of wood for its industrial arts shops, one town located in a forest region purchased standing timber and allowed its industrial arts classes to log it and move the timber to a nearby sawmill. There it was cut into lumber, allowed to season for several months and then used in the school industrial arts shops.[11] Since this direct method of relieving the lumber shortage

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[9]"Our Lumber Supply," Industrial Arts and Vocational Education, XXXVI (March, 1947), 136.

[10]Ibid.

[11]Archie J. Nicolette, "School Shop Class Makes Its Own Lumber," School Activities, XVIII (October, 1946), 47.

could apply only in a very limited number of cases, school shops must turn to other materials as replacement for or supplement to the use of wood. The ready availability of plastics make them a logical choice in this capacity. These modern materials of industry offer a versatility that is superior to both wood and metal. While wood and metal have limitations beyond which they cannot be used widely or well, plastics are chemically controlled and their limitations may be changed by altering the formula of ingredients that constitute them or by modifying the process used in their manufacture.[12]

Student Reaction to Working with Plastics

In schools where students have had the opportunity to work with plastics, student reaction has been that of eager acceptance. One of the reasons for this reaction is the large number of small projects that can be produced. Each project takes only a short amount of time and consequently the student does not tire of a project before it is completed. M. E. Williams of Cleveland, Ohio, says that plastics in the shop courses are greeted with enthusiasm by junior high school students.[13] Coleman Hewitt states that plastics are used in home mechanics and industrial arts classes in the Chicago

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[12] DeWick and Cooper, op. cit., p. ix.

[13] Mansperger and Pepper, op. cit., p. v.

Public Schools, and the students are pleased with the professional-looking results obtained. Hewitt also says that when given the opportunity to choose a material with which to work, the students usually choose plastics and quite frequently take some plastic material home to use in their leisure time or take an incompleted project home to finish it after school.[14] Louis Nisgore reports that plastics are very popular with students in a junior high school in New York City because of the hundreds of projects that can be made. Plastics also hold student interest because many projects can be completed. Nisgore states further that use of plastics causes his students to develop new ideas for designs.[15] G. M. Freeman states that for the school workshop there is no material which has more appeal for the pupils than the colored cast resins and that the younger pupils in the junior high school enjoy completing small projects such as rings, pins, and necklaces.[16] E. B. Hovey, Jr. reports that students experience a thrill to discover heated Plexiglas can be formed into any shape which they desire to form it and that work with plastics will create a favorable first impression which will encourage

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[14] Coleman Hewitt, op. cit., p. 55.

[15] Louis Nisgore, op. cit., p. 79.

[16] G. M. Freeman, "Plastics, a New Field of Interest," Texas Outlook, XXVI (February, 1942), 11-12.

additional exploration of the possibilities of this crafts material. Hovey recommends plastics handicraft as a good course for seventh and eight-grade boys.[17]

The above remarks are typical of those made by industrial arts instructors who are using plastics in their courses. A general trend indicated is that courses in plastics are particularly desirable for students in junior high school where handwork rather than machine work is emphasized. However, use of plastics is by no means confined to the younger students and may be used in high school or college courses. In view of the student reaction which these industrial arts instructors have encountered, those who contemplate launching an industrial arts plastics course need have little worry that it will not meet with quick student acceptance.

### Use of Plastics in Industrial Arts Courses Offer Opportunity for Design

Plastics are ideal materials with which to encourage the industrial arts students to produce original designs. The versatility of plastics and the many unexplored possibilities and uses of these materials offer incentive to the students to deviate from conventional designs and to try experimental designs of their own. An advantage that plastics offer to encourage original designs is that only a short period of time

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[17] E. B. Hovey, Jr., "Short Course in Plastics," Industrial Arts and Vocational Education, XXXVI (November, 1947), 390-392.

and a small amount of money are necessary to make a plastic project; therefore, the students will be more willing to undertake designs of their own since little time and money will have been spent should the designs prove unworkable.

While students are developing their knowledge of handling tools in working with plastics, they should work with conventional projects such as paper knives and ash trays. But when the basic knowledge of working with plastics and the uses of the various plastic materials have been explored, the industrial arts instructor should encourage original designs, using the types of plastics most suitable for handicraft work. From simpler original designs the students may proceed to more complex projects such as those that utilize the light refraction chararacteristics of the acrylics.[18] In encouraging students to produce original designs, the industrial arts instructor must impress upon them that plastic materials should always be used as plastics. For example, plastics should not be carved to imitate bone handles for a knife when the use of a pleasing pattern of corrugations would be more original and true to the material.[19]

Plastics That May Be Used in Industrial Arts

The two most popular plastic materials for use in school and home shops bear the trade names of Plexiglas and Lucite

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[18] E. I. Du Pont de Nemours Co., Hobby Lobbying with Plastics, p. 6.

[19] DeWick and Cooper, *op. cit.*, p. 19.

and belong to the acrylic family group. Plexiglas and Lucite are substantially the same chemically and physically.[20] They are undoubtedly the most versatile of all fabricating plastic materials and offer the opportunity for the school and home craftsmen to apply creative design of their own.[21] The advantages of Plexiglas are its clarity, strength, and ease of forming. It can be formed like rubber when heated to a temperature above the boiling point of water. When shaped after heating, Plexiglas will retain its new form after cooling. If the Plexiglas is then re-heated, it will return to its original shape. This characteristic is known as "elastic memory" and permits the salvage of pieces of Plexiglas formerly heated to other shapes. Beautiful effects can be obtained with Plexiglas by faceting, edge-lighting, and light-piping. It can be dyed any color and is inert to the action of most chemicals, mineral acids, strong alkalid, and solutions of most common chemicals do not harm it. Plexiglas is also impervious to kerosene, hexane, and white gasoline, but gasoline containing tetraethyl lead, aviation gasoline, concentrated alcohol, benzene, acetone, carbon tetrachloride, and lacquer thinner will harm this material. Its excellent insulator characteristics make Plexiglas ideal for high-voltage

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[20] Andrew J. Lockrey, op. cit., p. 1.

[21] Stanley F. Schneck, "Course in Plastics," Industrial Arts and Vocational Education, XXXVII (March, 1948), 114-115.

demonstrations in electricity classes, serving both as a transparent safety shield and insulator.[22]

Since the two materials, Plexiglas and Lucite, are so similar, it may be said that the aforementioned characteristics of Plexiglas are also applicable for Lucite. Characteristics of Lucite which are emphasized by its manufacturer are its light weight, shatter-resistance, strength, and pleasantness to the touch. Lucite can easily be kept lustrous, is resistant to chemicals, is readily machined or molded, has excellent optical properties, and is available for purchase in transparent, translucent, and opaque colors with a variety of surface patterns.[23]

Tenite.--Another material which can be used in school shops is also a thermoplastic of the acrylic group with the trade name "Tenite." This material has a wide variety of industrial and decorative uses and in addition to the general characteristics of thermoplastics, Tenite is a very tough material having a high impact strength and resistance to breakage under sudden, sharp blows. It may be punched, sawed, drilled, riveted, and may also have metal crimped to it. Tenite can be cemented to make a bond as strong as the material itself. This material supports combustion with

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[22] Rohm and Haas Company, Working with Plexiglas, p. 5.

[23] E. I. Du Pont de Nemours and Company, All that Glistens Is not Du Pont "Lucite," p. 5.

difficulty and is unaffected by ordinary temperatures. Tenite is unaffected by vegetable and mineral oils but its surface is spotted by alcohol and can be damaged by concentrated acids and alkalies. Many projects can be made in the school shops from Tenite such as clothes hangers, table edgings, and numerous other items for which its particular characteristics are most suited.[24]

Catalin.--Thermosetting plastics as well as thermoplastics may be used in school shops. One of these materials is Catalin which is a fine material for craftsmanship use. It has gem-like appearance and eye-appealing richness of color and resembles natural precious or semi-precious stones when highly polished. Catalin is strictly non-inflammable and from this standpoint is safer than any other plastic material. This characteristic makes it an excellent material for such projects as ashtrays. Other characteristics of this material are its light weight and toughness; it may be worked in very thin sections and curved to a desired radius in hot water provided discretion is used in the bending process to prevent breakage. Catalin is available to shop instructors in many special shapes with hundreds of castings suitable for knobs, handles, rings, bracelets, jewel boxes, and many other projects. This material can be cut readily, also drilled, tapped, turned,

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[24] DeWick and Cooper, Plastic Craft, p. 7.

carved, sawed, or polished; it can be washed without injury in water that does not contain strong alkaline cleaners. Catalin should not be heated, for it will char when heated above the temperature of boiling water.[25]

Bakelite cast resins.--Bakelite cast resins are another type of thermosetting plastics which can be adapted readily to use in school shops. These resins are noted for their depth of color and beauty in their finished forms. They are pure resins with pigments added to give mottles, striated tones, and varying degrees of transparency. Bakelite cast resins are not formed under heat and pressure but are formed in open, gravity, lead molds. They are made in a wide range of colors including natural amber, amethyst, blue, ebony, green, ivory, marble onyx, red, tortoise shell, and pearl. Any combination of colors is available in transparent, opaque, or translucent form. Bakelite cast resins may be machined or polished in much the same way as brass or ivory and may be drilled, sawed, turned on a lathe or screw machine, embossed, tapped and threaded, slotted, carved, and highly polished. Shop instructors may purchase these Bakelite cast resins in many standard sizes of rods, shapes, and tubes.[26]

Castolite.--For the school shop instructors who wish to introduce the casting of plastics into industrial arts courses

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[25] Ibid., p. 15.

[26] Ibid., p. 13.

a material known as Castolite is available which is excellent for this purpose. Castolite is a liquid resin which may be used in the following manner without the necessity of heating. A given quantity of Castolite is poured into a measuring cup and a given number of drops of hardener is added. The liquid is then poured into a clean dry mold where it is allowed thirty minutes to solidify at room temperature. The mold and resin casting are then placed in a covered box and heated by an ordinary electric light bulb for thirty minutes. The finished casting may then be removed from the mold and can be shaped, drilled or polished. The cost of Castolite is low for small projects and the excellent results which may be obtained will give the students incentive to try other jobs with this material and strive for improvement.[27]

The plastic materials that have been mentioned above are by no means the only plastics which can be used in school shops but are considered to be the plastics most readily adaptable for this purpose. Examples of other materials that can be used include Koroseal, a plastic sheeting material, which can be used for upholstery and the laminates which can be used in conjunction with wood or metal in other phases of shop work.

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[27] "Casting of Plastics in School and Home Workshop," Industrial Arts and Vocational Education, XXXV (October, 1946), 376.

## How Plastics Can Be Adapted to the Industrial Arts Program

There are a number of ways in which plastics can be used in the school industrial arts program, especially in handicraft courses. An entire course may be built around plastics, or they may be only one of several materials used in a general handicraft course. By no means, however, are plastics confined to use in handicrafts since plastic materials may be used in combination with wood or metal to become a part of other industrial arts courses.[28] Plastic sheet materials may be used in upholstery and will outwear most other upholstering materials. Plastics can also be used in the electricity courses for a variety of uses.

Plastics as a handicraft material.--When plastics are used for handicraft material there are hundreds of projects that can be made with a minimum of tools and equipment. Plastics began to come into prominence as a handicraft material during World War II when servicemen began using plastics in the handicraft shops in U. S. O. servicemen's centers. This interest of returning servicemen popularized the hobby of working with plastics in home workshops.[29] Also during the war, school shop instructors in search of materials for

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[28] Ibid.

[29] E. I. DuPont de Nemours, Hobby Lobbying, pp. 1-2.

substitutes for scarce wood and metal turned to scrap plastics and found them excellent for handicraft work in the schools.[30] After World War II ended, plastics were not dropped from the list of industrial arts materials when wood and metal again became available. Instead, plastic materials have increased in popularity and found more widespread use. One reason for this increasing popularity is the great variety of handicrafts projects which may be inexpensively made. Some of the many plastic projects which may be made by industrial arts handicraft classes are listed below.

Typical Plastics Projects[31]

| <u>For Beginners</u> | <u>For Advanced Workers</u> |
|---|---|
| Ash trays | Bookends |
| Belt hook | Cake server |
| Bracelet | Candlesticks |
| Cigar and cigarette holder | Chess set |
| Coaster | Cigarette box |
| Cookie cutter | Clock case |
| Curtain rings | Costume jewelry |
| Curtain tie-back | Cream and sugar set |
| Cut flower holder | Knife handle |
| Dice | Lamp and lamp shade |
| Door knob | Mirror case |
| Drawer pull or knob | Necktie rack |
| Earrings | Pen set |
| House numbers | Picture frame |
| Key ring | Place mats |
| Napkin ring | Radio case |

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[30] Coleman Hewitt, *op. cit.*, p. 55.

[31] J. V. Adams, *Plastics Arts Crafts*, p. 127.

Nail buffer
Name plate
Paper knife
Paper weight
Pendant
Poker chips
Shoe horn
Tie rack
Towel rack
Wall plaque
Salad set
Salt and pepper shakers
Serving tray
Shower curtain
Sugar scoop
Tableware
Tissue holder
Trays

It is preferable for the beginning craftsman to make projects which do not require machine processes, no intricate forming, and no cementing. Smaller projects like earrings, pendants, and bracelets are usually favorite items for the beginner. As the student develops skill in working with plastics he will discover that only the boundaries of his own imagination limit his designing new projects.[32]

Plastics Used in combination with other materials of Industrial Arts.--Plastic materials that may be used extensively in woodworking courses are the laminates. These laminated plastics which are finding many uses in the manufacture of furniture by commercial furniture-makers can well be adapted to furniture-making in industrial arts. Some applications for which laminates can be used are table tops, scuff pads, lamp bases and other uses. Working with laminated plastics is similar to working with wood for laminates may be cut with a standard woodworking bandsaw or circular saw without lubricants. When cutting laminates with a bandsaw, a

[32] Rohm and Haas Company, Working with Plexiglas, p. 5.

blade with a medium set is recommended for straight cuts and a heavy set is recommended for circular cuts.[33] Laminates may be obtained in a variety of forms including sheets, rods, and rectangular tubing. There are also a number of applications of plastic laminates in electrical insulation.[34]

There are a number of projects in which the acrylics or cast phenolics can be used in combination with other phases of industrial arts. Some of these examples are given below.

1. An end table or coffee table with a solid transparent plastic sheet for a top and bent tubular metal for a frame and legs.[35]

2. A table with a circular wood top and plastic rods for legs.[36]

3. An ottoman with plastic legs and an upholstered top.[37]

4. A fluorescent desk lamp with a metal shade and plastic sheet or rod to form the supporting column for the shade and fluorescent tube. The rods are set in a wood base.[38]

5. Metal tubular porch furniture with plastic lace webbing to form the seat.

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[33] General Electric Company, Texolite Laminated Plastics, pp. 50-63.

[34] Ibid., pp. 6-10.

[35] Chris H. Groneman, Plastics Made Practical, p. 314.

[36] Ibid., p. 299. [37] Ibid., p. 306. [38] Ibid., p. 289.

6. A serving tray made of walnut, mahogany or maple with side rails and handles made of plastics of contrasting colors.[39]

These are but a few of the combinations that can be achieved by using plastics in conjunction with other courses in industrial arts. The student is challenged with the opportunity to create new designs using plastics in combination with other materials.

## Processes and Tools Used in Working with Plastics

There are seven major processes used in working with plastics: sawing, sanding and buffing, heating, cementing, dyeing, machining, and undercutting or internal carving. An important factor to consider in view of the high prices of new machinery and equipment is that existing tools and equipment in the school shop may also be used for plastics. Plastics can be sawed, planed, scraped, filed, or sanded as in working with wood or they may be drilled, tapped, threaded, or turned as in working with metal.[40] Plastics may be worked entirely with hand tools which makes these materials particularly useful for classes in the junior high schools. More advanced students may work with plastics using machine tools.

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[39] A. Dunham, Working with Plastics, p. 97.

[40] Coleman Hewitt, op. cit., p. 55.

Minimum tools required for a class in plastics.--The minimum tools considered necessary for launching a course in plastics include the following:

1. A set of files
2. A set of bits
3. Hand drill
4. Fretsaw, hacksaw or any fine-tooth saw
5. Buffing and polishing compounds
6. Cement
7. Rags
8. Felt polishing sticks (homemade)
9. Miter box for sawing cylinders [41]

When power tools are available for use in working with plastics, table saws, jig saws, lathes, jointers, and other machine tools may be used. However, if a shop course in plastics is just being started, the most important power tool which should be purchased is a buffing wheel. This tool eliminates tedious hand polishing. Grinding wheels used with plastics should be coarse since finer wheels will clog and may burn the material.[42]

Sawing.--In working with plastics, saws with little or no set are preferred. When power saws are used, a hollow ground blade is most suitable for straight line cutting. Frictional heat must be kept in mind when using a power saw to prevent burning the plastics by feeding the material to the saw too rapidly. Sawing of plastics up to one-sixteenth

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[41] Andrew J. Lockrey, Plastics in the School and Home Workshop, pp. 15-26.

[42] Ibid.

of an inch may be eliminated for they can be heated to a pliable state and cut with scissors.[43]

Sanding and buffing.--Filing and dry sanding followed by wet sanding may be used for removing frosted edges left by sawing. The plastic material may then be buffed with a loose muslin wheel but must be kept moving to avoid scorching. After buffing, the material may be hand-polished with a flannel cloth. To protect the highly polished surface which results, wax with water emulsion may be applied by hand operation.[44]

Heating.--For heating thermoplastics for bending and shaping, any kitchen oven may be used. To prevent blistering, the plastic materials, an asbestos pad should be placed on the wire grate. Cotton gloves should be worn by the students or shop instructor to prevent burns when handling the hot plastics and to prevent scratching of the plastic material through careless handling. Before the plastics are placed in the oven, the oven should be preheated to 225-350°F. When the thermoplastics become flabby and pliable, they may be removed from the oven and formed on a jig. Jigs which will serve well may be made of pinewood and covered with flannel or felt. Unlike thermosetting plastics such as cast phenolic

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[43] Stanley F. Schneck, "Course in Plastics," Industrial Arts and Vocational Education (March, 1948), 114-115.

[44] Ibid.

resins which must be formed in hot water, thermoplastic acrylics do not need to be handled in this way. When the acrylics are removed from the oven they should be handled speedily and held in the desired form until cold. The plastics should be waved through the air several times before placed in the wood form to harden the outer surface slightly and prevent form offset. Water may be poured on the thermoplastics to speed up cooling. If the first shape obtained is not right, the plastic may be re-heated and it will then return to its original flat shape.[45]

Cementing plastics.--For cementing cast phenolic resins, different types of cement and technique of cementing must be used than those used for acrylics. Cements for cast phenolic resins are liquid resin which will harden when used with an acid accelerator. Either transparent or opaque cements may be used. Transparent cement requires a special acid accelerator, while hydrochloric acid can be used with opaque cement. Surfaces to be joined must be perfectly flat with snug fitting joints which must be sanded smooth. Since polished surfaces will not hold when cemented, it is necessary to scratch the surface of the polished resin several times with a sharp-pointed scriber at the point where it is to be cemented. For best results and for proper alignment a 3/16 inch long piece

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[45] Ibid.

of #16 gauge wire should be used as a dowel between the two surfaces to be cemented. This will prevent "creeping" of the freshly cemented joint when clamps are applied. Only the quantity of cement needed for one job should be mixed. A match or glass rod should be dipped into the cement and then into the acid accelerator. The two are then mixed together on clear glass and applied immediately to the surfaces to be joined. After the two surfaces are pressed together, clamps should then be put in place with cardboard protecting the surface of the plastic from scratches. Surplus cement should be quickly removed with a damp cloth or carefully scraped off if it has already set. The cemented joint will set at room temperature after four to ten hours but should not be machined until the following day.[46]

For cementing acrylics such as Plexiglas and Lucite, the manufacturers recommend different cements for their particular product, but the same technique of cementing may be used for both Plexiglas and Lucite. E. I. Du Pont de Nemours Company, the manufacturers of Lucite, make and recommend H-94 cement for use with Lucite. This is a solvent type of cement which softens the surface of the Lucite in two to five minutes. When the cementing is done, the piece may be handled within one hour and machined within five hours. Rohm and Haas Company, the manufacturers of Plexiglas, make several

[46] Raymond Cherry, General Plastics, Projects and Procedures, pp. 33-34.

types of cement which they recommend for use with Plexiglas. The two types which may best be used in school or home workshops are known as "Cement I-A" and "Cement I-C." Cement I-A produces the strongest joints and should be used when the part is subsequently to be formed, machined, or sanded. Joints with 75 per cent of the tensile strength of Plexiglas can be produced by using Cement I-A. Cement I-C can be used where the strength of the joint is not critical, for it produces joints with lower tensile strength, but this cement is more easily used than Cement I-A.[47]

There are two methods of using Cement I-A or Cement I-C. The first method is called "soak" cementing and the procedure is as follows. The two surfaces to be joined are sanded or machined smooth until they fit accurately. Masking tape is applied carefully to those areas not to be soaked so that the soaking will be confined to those areas to be joined. The Plexiglas is then immersed in the cement and soaked for three to fifteen minutes when using Cement I-A. When using Cement I-C, the soaking time is from thirty seconds to five minutes. When the two pieces are removed from the cement they should be joined immediately before the cement evaporates. The two pieces should be held together for fifteen to thirty seconds before applying pressure and should then be clamped

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[47] Rohm and Haas Company, Cementing Plexiglas, pp. 1-7.

together with just enough pressure to force out air bubbles. The cemented assembly should be left in the clamping jig for approximately four hours and the masking tape should be removed immediately after clamping. The second method of joining Plexiglas is known as "glue cementing." Clean chips and shavings of Plexiglas are added to Cement I-A until it has the consistency of syrup. It can then be applied like glue to the two surfaces to be joined with the excess solvent softening and forming a cushion on both surfaces.[48]

<u>Dyeing plastics</u>.--The process of dyeing plastics is a very simple one with the exception of dyeing laminates. To dye acrylics the material is immersed in dye for a short time and then it is removed and immersed in water and washed thoroughly. Another method is to brush the dye on the plastics. It is a characteristic of acrylics that the entire piece absorbs the dye and is not just surface-dyed. Proportions for making the dye solution are ten parts of water to one part of soluble dye. This same solution may be used indefinitely but it should be strained after repeated usage. Before being immersed in the dye the acrylic should be heated to 190 degrees Farenheit to speed absorption of the dye.[49]

The process of dyeing laminates is more time-consuming and difficult. Two pieces of transparent laminated plastics

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[48] <u>Ibid</u>.

[49] Stanley F. Schneck, <u>op</u>. <u>cit</u>., pp. 114-115.

of the same size should be used. After the two faces to be dyed have been cleaned with rubbing alcohol, these faces should be flooded with dye, using a small brush, then dried for thirty seconds. A second coat of dye should then be applied and the two surfaces pressed together immediately and allowed to dry for one to two hours. After sanding and buffing the edges, the result is a solid piece of plastic with the color inside. A variation of this same procedure involves using two or more colors on the same face, then sliding one piece over the other. This will result in a blending of the colors.[50]

<u>Undercutting or internal carving</u>.--Undercutting or internal carving is a process where flowers, leaves, and other designs are carved into plastic stock, using a tapered twist drill. This operation must be done with a power drill and requires careful workmanship. The operation is done by drilling up from the bottom side of the plastic stock and moving the drill slightly from side to side to form patterns such as floral design patterns or leaves. A frosted white design will result and this may be colored with drops of dye. If the drops of dye are preceded by drops of water, a frosted edge pattern will result. Another variation may be achieved by adding drops of a darker dye over a lighter color, such as the use of red drops over yellow, to produce a blended

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[50] *Ibid*.

effect. To drill plastics, a regular twist drill can be used but it should be re-ground to have a seventy degree lip angle. Thin soap may be used as a lubricant. Auger bits should not be used for drilling plastics, but plastics may be routed or shaped by using the same procedure as when working with wood.[51]

<u>Machining plastics</u>.--The rules of good machining apply to plastics much the same as they do to metal or wood. The working qualities of acrylic plastics are similar to those of brass or copper. Cutting edges of tools used on plastics should have no rake but should have a scraping rather than cutting action. The use of coolants is usually not necessary but when coolants do need to be used, soap and water are the preferred ones. Those persons who have had experience in using woodworking lathes or engine lathes will have little trouble in working plastics. It is preferable to work plastics on a small lathe, if this type of machine is available, for usually the material being worked is of small diameter. Plastics can be held in engine lathes in the same manner as metal and machined to close tolerances. When machining plastic tubing, one end of the material may be mounted in a chuck and a pipe center may be used to support the other end. Plastics can also be drilledand polished on lathes.[52]

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[51] *Ibid.*

[52] Raymond Cherry, *op. cit.*, pp.50-54.

When working plastics on a woodworking lathe, all tools may be used except the gouges. The round nose chisel is the most valuable tool for working with plastics. A woodworking lathe can be used also for sanding plastics with abrasive cloth and polishing with a soft cloth.[53]

To drill plastics on a drill press, a bit of a seventy degree lip angle is preferable to the standard fifty-nine degree lip angle. The flute angle can also be re-ground to have a negative rake. For higher cutting speeds or when drilling deep holes, the plastic must not be allowed to become hot because this will make an imperfect hole and may cause the drill to stick. In order to prevent this, the drill should be withdrawn at every half-inch depth to clean the hole of chips and to allow the plastic to cool for a few seconds. Plastics should be backed with a scrap of wood when being drilled, if the hole goes through the entire piece.[54]

Plastics may also be cut on a jointer like wood although speeds should be around 4200 revolutions per minute. Safety precautions that apply to joining wood also apply to joining plastics. Edges of the plastic may also be beveled as well as squared with the face of the sheet. When joining plastics, the knives in the cutterhead should be very sharp. Care should always be taken to see that the

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[53] Ibid.

[54] Ibid., p. 55.

table and fence of the jointer are smooth to prevent the plastic material from being scratched.[55]

### Interests May Be Developed from Working with Plastics

Plastics as an avocation.--Plastics handicraft is constantly gaining favor, as a hobby. In recent years, interest in plastics has grown to such an extent that at the end of the day in the factory or in the office, many people now work with plastics or some other handicraft material in the basement or home workshop merely as a hobby. It is significant that plastic materials are available to these craftsmen just at the time when there is much revived interest in handicrafts. Although plastics were developed primarily for industrial uses, they lend themselves well to the purposes and techniques of the handicraftsman, and no other material for handicraft work offers the possibilities that plastics do. With many possible uses still to be explored, plastics are rapidly becoming a leading crafts material.[56] The student who learns to work with plastics in an industrial arts plastics handicraft course may be provided with the foundation for a satisfying and useful avocation.

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[55] *Ibid.*, pp. 56-57.

[56] Clark N. Robinson, *Meet the Plastics*, pp. 119-120.

Plastics as a vocation.--The student who chooses to enter the plastics field as a vocation must first of all have an interest and aptitude for working with plastics. If he finds that this interest and aptitude is strong enough, there are a variety of jobs which may be secured in the plastics industry. In the molding division of the industry which employs the largest number of people in the plastics industry, the student may enter the chemical laboratory where workers continue to improve older plastics and search for new sources of materials convertible to plastics. In the factories, jobs in plastics include press operators, finishers, inspectors, mold and product designers, moldmakers, engineers and draftsmen. Press operators operate the various compression, injection, extrusion, and other machines used to shape plastics. Finishers take the roughly completed articles and finish them for sale by filing, sanding, and polishing. For those persons competent in determining whether or not satisfactory articles are being produced, there is room for advancement to foremen and production superintendents.[57]

For the person who has had experience in working with plastic materials, one of the most attractive jobs available is that of mold-maker. These molds for plastics are made by

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[57] Society of the Plastics Industry, Plastics, the Story of an Industry, pp. 27-28.

expert machinists from hardened tool steel, are highly polished, and are often held to tolerances of 1/10,000 of an inch.[58] Mold and die-makers are in great demand, and there will be an increasing need for these men as the industry continues to grow.

The fabricators division of the industry offers the most openings for employment in the plastics industry at the present time. There is a need for persons to do bending, buffing, and painting of plastics; employees for operators of saws, drills, lathes, and foot presses are also in demand. Fabricators supply industrial and electrical firms , stores, and other corporations with plastics products and need engineers, designers, draftsmen, and sales personnel. In the plastics industry the work is not seasonal, nor is it considered hazardous.[59]

Importance of education and training in finding a job in the plastics field.--For the person who chooses the plastics field as a career, education is very important. The higher-paying positions go to those with mechanical or chemical engineering training, but the plastics industry employs many persons with only grammar school or high school

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[58] A. Dunham, Working with Plastics, pp. 208-212.

[59] Society of the Plastics Industry, Plastics, The Story of an Industry, pp. 28-29.

education. These people who may enter the industry as press operators may through work and study advance to more skilled jobs as mold-makers and perhaps eventually to positions as mold-designers or other higher paid work.[60] The training and experience gained in an industrial arts plastics course in learning the properties of the various plastics, how to machine plastics, and how to design new plastics products will aid the person who has had this training to step into a better-paying position. Without this training, he might become no more than just another unskilled laborer in an industry which for the present and future offers great promise to those choosing the plastics industry as a career.

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[60] *Ibid*., p. 29.

## CHAPTER V

## CONCLUSIONS AND RECOMMENDATIONS

The following conclusions have been reached from the review of the growth of the plastics industry and from a study of the many uses of plastic materials by industry and by individual consumers:

1. The plastics industry is one of the United States' most promising growing industries.

2. John Wesley Hyatt is credited with launching the thermoplastics industry by his development of "celluloid" in 1868. Dr. Leo H. Baekeland in 1909 developed the first thermo-setting plastic and started an industrial firm to manufacture this material known as "Bakelite."

3. The plastics industry has increased in size by 2000 per cent since the beginning of the twentieth century.

4. Thermosetting plastics and thermoplastics have thousands of industrial uses. Many of the uses could not be accomplished with any material except plastics.

5. In 1951 there are more than thirty types of plastics and 672 trade names for plastic materials.

6. The increased industrial activity during the 1920's was responsible for the beginning of the modern-day plastics industry.

7. The plastics industry is one of the few industries which grew and expanded during the depression years in the 1930's.

8. Plastics production increased fourfold during World War II and has doubled in size during the postwar period.

9. The plastics industry is made up of four divisions consisting of material suppliers, molders, fabricators, and laminators.

10. The trend in the plastics industry is for continued growth, and the outlook for the future of plastics is excellent.

11. Large industries such as the electrical, chemical, automotive, and refrigeration are increasing their uses of plastics. The versatility of plastic materials is responsible for industry's choice of plastics for so many manufacturing applications.

12. Plastics have enabled improvement of existing products. An example of this is the use of plastic adhesives in the manufacture of plywood which now permits exterior uses of this material which was once confined exclusively to indoor uses.

13. There is a need for consumer education to acquaint the buying public with the advantages and also with the limitations of plastics.

14. There is a need for study and work with plastics in the schools in order to meet the needs of youth.

15. Plastics should be used in the schools' industrial arts program because of their importance as industrial materials and to achieve the objective of a functioning industrial arts program.

16. The plastics industry may serve as an example in teaching how industry grows in the United States.

17. Plastics may be used in several courses in industrial arts but are particularly well suited as a handicrafts material.

18. Student reaction to working with plastics has been favorable in industrial arts classes where the materials have been introduced.

19. There are a number of plastics which may be used in industrial arts including both thermosetting and thermoplastic materials.

20. Existing tools and equipment in industrial arts shops may be used to work plastics.

21. The seven major processes used in working plastics are sawing, sanding and buffing, heating, cementing, dyeing, machining, and undercutting or internal carving.

22. Work with plastics in industrial arts may aid the student in developing an interest in plastics handicraft as an avocation or it may provide him with the background for a vocation.

## Recommendations

In view of the increased importance of plastics as industrial materials and their possibilities for use as materials in the industrial arts program, the following recommendations are offered:

1. Every school's industrial arts program should include work with plastics. If plastics cannot be included as a separate handicraft course, the use of these materials should be integrated into general crafts classes or used in combination with wood or metal in other industrial arts classes.

2. Plastics should be used in the junior high school shops where emphasis is on handwork rather than on machine work.

3. Students should be given the opportunity to work with a variety of plastic materials and should be encouraged to develop original designs using these materials.

4. Laminates should be introduced into woodworking classes to be used as materials for furniture-making and other applications for which they are particularly suited.

5. A study of the many uses of plastics should be included in industrial arts plastics courses to acquaint the student with the many ways in which plastic products serve the consumer and to aid the student in making wise selections when purchasing these products.

6. Those students who plan to make a career in the

plastics field should be advised to take courses in chemistry to gain knowledge of the chemical composition of plastics.

## BIBLIOGRAPHY

### Books


Adams, John V., Plastics Arts Crafts, New York, D. Van Nostrand Company, 1948.

Cherry, Raymond, General Plastics, Projects and Procedures, second edition, Bloomington, Illinois, McKnight and McKnight, 1947.

De Wick, Earnest S., and Cooper, John H., Plastic Craft, New York, Macmillan Company, 1946.

Du Bois, John H., Plastics, revised edition, Chicago, American Technical Society, 1943.

Dunham, Arthur, Working with Plastics, New York, McGraw-Hill Book Company, 1948.

Groneman, Chris H., Plastics Made Practical, Milwaukee, Bruce Publishing Company, 1948.

Hemming, Emile, Plastics and Molded Electrical Insulation, New York, The Chemical Catalog Company, Inc., 1923.

Leyson, B. W., Plastics in the World of Tomorrow, New York, E. P. Dutton and Company, Inc., 1944.

Lockrey, Andrew J., Plastics in the School and Home Workshop, third edition, New York, D. Van Nostrand Co., Inc., 1946.

Mansperger, Dale E., and Pepper, Carson W., Plastics Problems and Processes, second edition, edited by William H. Varnum, Scranton, Pennsylvania, International Textbook Company, 1942.

Modern Plastics Encyclopedia, 1949, New York, Plastics Catalog Corporation, 1949.

1950 Modern Plastics Encyclopedia and Engineer's Handbook, New York, Plastics Catalogue Corporation, 1950.

Plastics Catalog, New York, Plastics Catalogue Corporation, 1943, 1944, 1945.

Robinson, Clark N., Meet the Plastics, New York, Macmillan Company, 1949.

Rohm and Haas Company, Working with Plexiglas, Philadelphia, 1947.

Simonds, Herbert R., and Sherman, Joseph V., Plastics Business, New York, D. Van Nostrand Company, Inc., 1946.

Simonds, Herbert R., Weith, Archie J., and Bigelow, M. H., Handbook of Plastics, secon edition, New York, D. Van Nostrand Company, 1949.

Pamphlets

A Simplified Guide to Bakelite and Vinylite Plastics, New York, Bakelite Corporation, Unit of Union Carbide and Carbon Corporation, 1949.

All That Glistens Is not Du Point "Lucite", Wilmington, Delaware, E. I. Du Pont de Nemours and Company, Inc., 1948.

Cementing Plexiglas, Bulletin Number 7, Philadelphia, Rohm and Haas Company.

Designing with Plexiglas, Bulletin Number 14, Philadelphia, Rohm and Haas Company.

Dow Plastics, Midland, Michigan, Plastics Division, The Dow Chemical Company.

Du Pont Plastics, Wilmington, Delaware, Polychemicals Department, E. I. Du Pont de Nemours Company, Inc.

Geon in the Wire and Cable Industry, revised edition, Cleveland, Ohio, B. F.Goodrich Chemical Company, 1948.

Geon Polyvinyl Materials, Cleveland, Ohio, B. F. Goodrich Chemical Company, 1950.

Hobby Lobbying with Plastics, Reprinted from December, 1944, issue of Modern Plastics, Wilmington, Delaware, E. I. Du Pont Nemours, Inc.

How to Buy and Sell Plastics, revised edition, Washington, D. C., Plastics Materials Manufacturers Association, Inc., 1949.

Monsanto Plastics, Springfield, Massachusetts, Plastics Division, Monsanto Chemical Company.

Plastics - The Story of an Industry, second edition revised, New York, Society of the Plastics Industry, Inc., 1946.

Plexiglas Acrylic Plastic, Philadelphia, Rohm and Haas Company.

Plexiglas for Store Modernization, Philadelphia, Rohm and Haas Company.

Texolite Laminated Plastics, Pittsfield, Massachusetts, Plastics Division, Chemical Department, General Electric Corporation.

The ABC's of Modern Plastics, New York, Bakelite Corporation, Unit of Union Carbide and Carbon Corporation, 1946.

The Fabrication of Catalin, New York, Catalin Corporation of America, 1941.

Vinylite Resins and Plastics, New York, Bakelite Corporation, Unit of Union Carbide and Carbon Corporation, 1948.

What Are Plastics?, Pittsfield, Massachusetts, Plastics Division, Chemical Department, General Electric Corporation.

## Articles

Abbiati, F. A., "The Horn of Plenty Is Mechanized, "Monsanto Magazine, XXVI (October, 1947), 26-32.

"Acrylic Signs Threaten Neon," Modern Plastics, XXVII (January, 1950), 153.

"Admiral Cabinets Make History," Modern Plastics, XXVII (January, 1950), 145-146.

Batters, H. M., and Lee, J. A., "How Much Can Plastics Production Be Expanded," *Chemical and Metallurgical Engineering*, XLVIII (May, 1941), 128-131.

Broderson, N. O., *Modern Plastics*, XXIII (January, 1946), 94.

"Casting of Plastics in School and Home Workshop," *Industrial Arts and Vocational Education*, XXXV (October, 1946), 376.

"Cellulose and Resin Plastics," *Chemical and Metallurgical Engineering*, XLVI (February, 1939), 114-115.

Ellis, Carlton, "Less Familiar Aspects of the Plastics Industry," *Chemical and Metallurgical Engineering*, XXXV (January, 1928), 18-19.

Elicker, Paul E., "The Needs of Youth, " *School Executive*, LXVII (February, 1948), 48-49.

"Four Million Pounds a Year," *Modern Plastics*, XXVII (January, 1950), 114-116.

Freeman, G. M., "Plastics--A New Field of Interest," *Texas Outlook*, XXVI (February, 1942), 11-12.

Graham, J., "For Furniture with a Future," *Plastics News front*, IX (April, 1949), 10-11.

Greenwood, Donald B., "Plastics in the Industrial Arts Shops," *Industrial Arts and Vocational Education*, XXXVIII (October, 1949), 316-317; (November, 1949), 351-353.

Hewitt, Coleman C., "Plastics in the Schools," *Chicago Schools Journal*, XXIX (January, 1948), 53-56.

Hovey, E. B., Jr., "Short Courses in Plastics," *Industrial Arts and Vocational Education*, XXXVI (November, 1947) 390-392.

Kline, Gordon M., "History of Plastics and Their Uses in the Automotive Industry," *Modern Plastics*, XVII (July, 1940), 84090; (August, 1940), 58-61, 78-88.

McCann, Hiram, "Doubling-Tripling-Expanding, That's Plastics," *Monsanto Magazine*, XXVI (October, 1947), 4-8.

Nicolette, Archie J., "School Shop Class Makes Its Own Lumber," *School Activities*, XVIII (October, 1946), 47.

Nisgore, Louis, "Use of Plastics in Our Industrial Arts Program, "Industrial Arts and Vocational Education, XXIX (September, 1947), 79.

"Our Lumber Supply," Industrial Arts and Vocational Education, XXXVI (March, 1947), 136.

"Plastics," Chemical and Metallurgical Engineering, L (February, 1943), 108-109.

"Plastics and Rayon Prepare for Peacetime Progress," Chemical and Metallurgical Engineering, LIII (January, 1946), 106-107.

"Plastics in 1941," Chemical and Metallurgical Engineering, XLVIII (February, 1941), 98-100.

"Plastics Made Satisfactory Record in 1932," Chemical and Metallurgical Engineering, XL (January, 1933), 42-43.

"Plastic Materials," Chemical and Metallurgical Engineering, LI (February, 1944), 117.

"Plastics Use Moderate Decline to Plan Ahead," Chemical and Metallurgical Engineering, (January, 1931), 42-54.

"Plastics Play Promising Part in Equipping Modern Plant," Chemical and Metallurgical Engineering, XXXVI (September, 1929), 569-571.

Samaras, N. N. T., "Something Nature Could Not Supply," Monsanto Magazine, XXVI (October, 1947), 18-25.

Schneck, Stanley F., "Course in Plastics," Industrial Arts and Vocational Education, XXXVII (March, 1948), 114-115.

Skomp, A. R., "Use of Plastics in Our Industrial Arts Shops," Industrial Arts and Vocational Education, XXVI (June, 1937), 193-194.

Smith, Phillip H., "Plastics Come of Age," Scientific American, XLII (January, 1933), 5-7.

Stout, William B., "The Automotive Industry--What It Needs From the Plastics Industry," Modern Plastics, XXIII (January, 1946), 107-109.

Sweeney, Charles, "The World That Plastics Built," Monsanto Magazine, XXVI (October, 1947), 9-17.

Turnbull, James R., "In the Plastics Future," <u>Monsanto Magazine</u>, XXVI (October, 1947), 38-42.

Williams, Felix N., "The Peak Is Not Yet," <u>Monsanto Magazine</u>, XXVI (October, 1947), 2.

## Reports

U. S. Department of Commerce, Office of Domestic Commerce, "Plastic Materials," <u>Chemicals and Drugs</u>, pp. 45-46.

## Unpublished Material

Brenholtz, Gerald S., "Crafts in Education for Life Adjustment Situations," Unpublished Master's Thesis, Department of Industrial Arts, North Texas State College, 1949.

Sealy, Emma L., "Plastics, Their History and Use," Unpublished Master's Thesis, Department of Education, North Texas State College, 1946.

"Synthetic Resin Production," Society of the Plastics Industry, Inc., New York, 1950. Mimeographed.