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The Role of the Plastic Industry in Industrial Arts Education

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THE ROLE OF THE PLASTIC INDUSTRY IN INDUSTRIAL ARTS EDUCATION

by

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This thesis submitted by James E. Preston in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

Chairman

Dean of the Graduate School

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Statement of the Problem

The purpose of this study was to determine the historical development and scope of the plastics industry. It was also ascertained in this study how the plastics industry could be interpreted in industrial arts education programs.

Method of Study Used

A review of available literature was made to identify the history and scope of the plastics industry, processes, products, type and cost of equipment, and the availability of visual aids to be used in teaching industrial plastics.

Results

Industrial processes applicable to industrial arts education have been described in this study. Also, a course of study for industrial plastics has been developed for all industrial arts education programs.

Conclusion

It was concluded by this study that the plastics industry has had a major significance on society. Therefore, it is necessary that all youth be acquainted with it in industrial arts education.

CHAPTER I

DEFINITION AND EXPLANATION OF THE PROBLEM

Statement of the Problem

The purpose of this study was to determine the historical development and scope of the plastics industry. It has also been ascertained in this study how the plastics industry can or cannot be interpreted in industrial arts education programs through the processes, products, tools, and materials of the industry.

Answers to the following questions were sought as a means of giving emphasis to the chief aspects of the problem:

1. What is industrial plastics?
2. What is the historical development of the plastics industry?
3. Why should we include the plastics industry as a portion of the industrial arts education programs?
4. What industrial processes of the plastics industry can be feasibly taught in industrial arts education programs?
5. What are the limitations of teaching industrial plastics in industrial arts education programs?
6. What would the cost of initiating an industrial plastics program be in the industrial arts curriculum?

Nature and Explanation of the Problem

According to the Society of Plastics Industry, Inc., the industry has grown at a rate of approximately one billion pounds of raw materials annually.[1] This growth, plus the fact that the primary objective of industrial arts education is to interpret the major industries, has increased the need for all industrial arts education programs to include education in the field of plastics.

The industry is becoming alarmingly concerned over the lack of exposure to plastics education in the classroom.[2] There has been an accelerating growth rate in the field of plastics technology. Concurrent with this growth of the industry is the rapid change in programs of industrial arts education from a "Craft" to a "Science."[3] Plastic resins are used in the manufacture of many items in our society today, everything from combs to toothbrushes to automobiles to boats to space capsules. The raw materials used for each of these items are manufactured with the knowledge of chemistry.

In a pamphlet distributed by the Stevens Institute of Technology, the need for additional people educated in plastics technology was reported. A survey by the institute confirmed that the plastics industry is in need of additional personnel having both depth and breadth of knowledge in the field of polymer materials. So great has this need been, that many companies have been forced to train their

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[1]The Society of the Plastics Industry Inc. The Story of the Plastics Industry. (11th ed., Rev.). Edited by Don Masson. (New York: The John B. Watkins Co., June, 1966), p. 4.

[2]Dow Chemical Co. Letter from Dow Chemical on the Plastics Industry. January 1965.

[3]University of North Dakota. Course in industrial plastics, taught by Luvern Eickhoff, Fall, 1966.

own people, either in their own plants, or in a piecemeal fashion.[4] It is not implied here that industrial arts education programs should teach the students a vocation in plastics technology. What is implied, is that industrial arts education programs should acquaint students with the processes, products, tools and materials of the plastics industry.

Scope of the Study

This study was concerned with the historical development, identification of industrial processes, products, tools, and materials, and the scope of the plastics industry.

A review of literature was made to identify those industrial processes that are applicable to industrial arts education. A course of study has been developed in accordance with the findings and conclusions. The approximate cost and type of equipment needed to initiate a curriculum in the industrial arts education programs has also been identified.

Method of Study

The method of study used was that of documentary research. A review of available literature was made to identify the history and scope of the plastics industry, processes, products, type and cost of equipment, and the availability of visual aids to be used in teaching industrial plastics.

Sources of Information

The Chester Fritz Library and the Industrial Arts Department

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[4] Ibid.

Library at the University of North Dakota were used extensively to identify the historical development and scope of the plastics industry.

Information, (books, periodicals, reports, and essays) describing the industrial processes, products, tools, and materials, that are produced and used in the plastics industry, was received from various chemical and equipment manufacturing firms identified in Appendix I and II.

Need and Purpose of the Study

The basic assumption and objectives of industrial arts education is the interpretation of the major industries.[5] Major industries, meaning those industries which have the greatest significance and impact on society.

Industrial plastics education is a relatively new area in the industrial arts education curriculum. The plastics industry has had an influence and impact on society and it is necessary that it have equal emphasis with other major industries.

The purpose of the study was to determine the historical development and scope of the plastics industry. Also, it was the purpose to identify the processes, products, tools, and materials of the plastics industry which can be used in teaching industrial plastics in all industrial arts education programs.

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[5]American Council of Industrial Arts Supervisors, Industrial Arts Education (Illinois: McKnight & McKnight, 1963).

CHAPTER II

THE PLASTICS INDUSTRY

Historical Development

With the discovery of a process to manufacture a material called "Celluloid," the doors were open to an entirely new industry.

In 1869, due to a shortage of ivory for billiard balls, there arose a need for a good substitute material. John Wesley Hyatt, determined to solve the problem, met the need when he hit upon the idea of mixing pyroxylin, made from cotton and nitric acid, with camphor.[6] Hence, he developed "celluloid."

It was not until forty-one years later that the second major step was taken in the plastics industry. This step was in 1909, when Dr. Leo Henrik Baekeland introduced phenol-formaldehyde resins. According to The Society of the Plastics Industry Inc., the first phenolic in this country was given the trade name of Bakelite, in honor of Dr. Leo Henrik Baekeland.[7]

There have been many major break-throughs in materials discovered by the plastics industry since 1909.[8] Table 1 identifies each material, date of introduction, and an example of each materials' use.

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[6] The Society of The Plastics Industry Inc., op. cit., p. 2.

[7] Ibid.

[8] Ibid., p. 3.

TABLE 1

INTRODUCTION OF PLASTICS MATERIALS*

Date	Material	Example
1868	Cellulose Nitrate	Eye Glass Frames
1909	Phenol-Formaldehyde	Telephone Handset
1909	Cold Molded	Knobs and Handles
1919	Casein	Knitting Needles
1926	Alkyd	Electrical Bases
1926	Analine-Formaldehyde	Terminal Boards
1927	Cellulose Acetate	Tooth Brushes, Packaging
1927	Polyvinyl Chloride	Rain Coats
1929	Urea-Formaldehyde	Lighting Fixtures
1935	Ethyl Cellulose	Flashlight Cases
1936	Acrylic	Brush Backs, Displays
1936	Polyvinyl Acetate	Flash Bulb Lining
1938	Cellulose Acetate Butyrate	Irrigation Pipe
1938	Polystyrene or Styrene	Kitchen Housewares
1938	Nylon (Polyamide)	Gears
1938	Polyvinyl Acetal	Safety Glass Interlayer
1939	Polyvinylidene Chloride	Auto Seat Covers
1939	Melamine-Formaldehyde	Tableware
1942	Polyester	Boat Hulls
1942	Polyethylene	Squeezable Bottles
1943	Fluorocarbon	Industrial Gaskets
1943	Silicone	Motor Insulation
1945	Cellulose Propionate	Automatic Pens and Pencils
1947	Epoxy	Tools and Jigs
1948	Acrylonitrile-Butadiene-Styrene	Luggage
1949	Allylic	Electrical Connectors
1954	Polyurethane or Urethane	Foam Cushions
1956	Acetal	Automotive Parts
1957	Polypropylene	Safety Helmets
1957	Polycarbonate	Appliance Parts
1959	Chlorinated Polyether	Valves and Fittings
1962	Phenoxy	Bottles
1962	Polyallomer	Typewriter Cases
1964	Ionomer	Skin Packages
1964	Polyphenylene Oxide	Battery Cases
1964	Polyimide	Bearings
1964	Ethylene-Vinyl Acetate	Heavy Gauge Flexible Sheeting
1965	Parylene	Insulating Coatings
1965	Polysulfone	Electrical/Electronic Parts

*Courtesy The Society of The Plastics Industry Inc.

The plastics industry has grown into a billion dollar industry since John Wesley Hyatt's discovery of "Celluloid." The industry has been growing by about one billion pounds of produced raw materials each year since 1955.[9] This growth is represented in Table 2.

The significant growth in the plastics industry occurred during World War II. Growth of the industry started due to the shortage of rubber and other badly needed materials during the war. Following the war this material was used for domestic consumer products. Plastics as a rule had not been accepted by the general public as good substitutes for other well known materials such as wood, metal, glass, rubber, etc., until after the war.[10]

The plastics industry has gone through the novelty and gadget stage of its growth. Many years ago plastics became an important part of the electrical and communications field and continues to be so today. Plastic molded parts are now considered vital components in the development of electronic, missile, and military equipment.[11]

Engineers have always sought, and will continue to seek, materials which have a high strength to weight ratio. Plastics materials satisfy this very important property. The future of the industry holds infinite possibilities because of this fact alone. If technical improvements continue to be made in the future as they have

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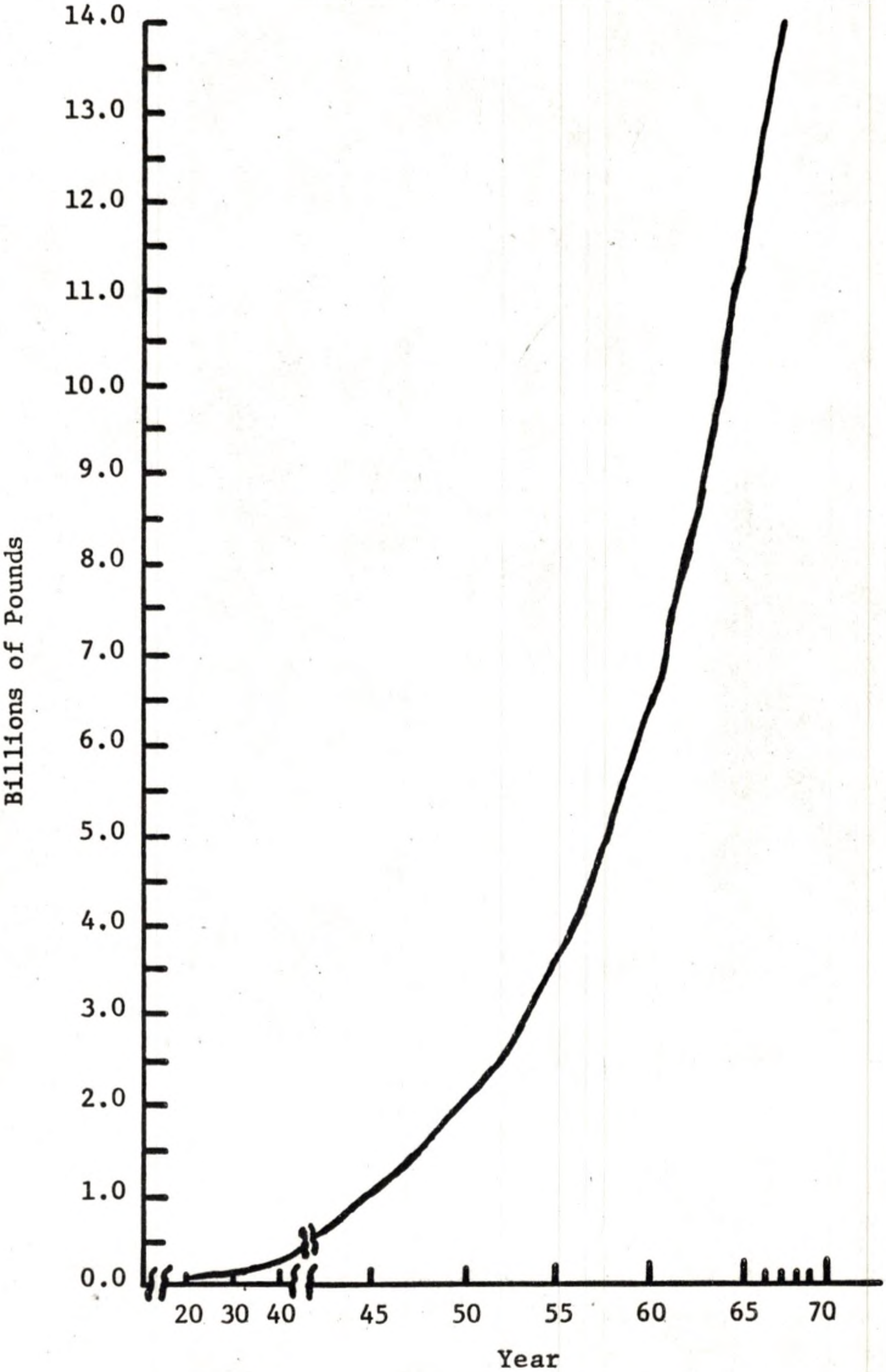
[9]The Society of the Plastics Industry Inc. General Bulletin for members. Bulletin no. 997. A bulletin prepared by the Society of the Plastics Industry Inc. January, 1967.

[10]Alfred Lewis, The New World of Plastics. (New York: Dodd, Mead and Company, 1963), pp. 24-25.

[11]Denis A. Deale, Opportunities in Plastic Careers (New York: Universal Publishing Corp., 1963), p. 28.

TABLE 2

RAW SYNTHETIC MATERIALS PRODUCTION*



*Courtesy The Society of the Plastics Industry based on U. S. Tariff Commission Reports.

in the past, it will not be long before plastics will play an even greater role in such fields as building construction, automotive manufacture, missiles, and aeronautics.[12]

The plastics industry is divided into two main groups of activity--namely the raw materials manufacturers and fabricators or molders of these materials. The fabricators or molders are further divided into three main categories, (1) custom molders, (2) consumer molders, and (3) custom consumer molders. Custom molders are concerned with molding and fabricating plastics for others. Consumer molders are molders who mold and fabricate plastics for their own consumption. Custom and consumer molders are molders who mold and fabricate plastics for others as well as for their own consumption.[13]

If we were to describe the importance of the plastics industry today, a quotation that was written in 1936 by Dr. L. H. Baekeland would best serve this purpose. This quotation was true in 1936 and is undoubtedly true today.

> Twenty-five years ago, one could hardly predict the importance that the plastics industry would attain in the world today. There was a mere handful of industries wherein the new materials might be used to advantage. As the months passed, other applications suggested themselves and proved their feasibility. And now there is hardly any field, any branch of industry where plastics are not serving faithfully in one form or another.
>
> When chemical research is stimulated, it advances our knowledge in many fields other than the original objective. The synthetic plastics industry has broadened day by day, and exploration is now being carried on in widely different and seemingly unrelated fields.
>
> Able scientists and chemists throughout the world are devoting their untiring efforts in many branches of

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

[13]University of North Dakota, *op. cit.*

scientific chemical research. Where their research will lead, one can only conjecture. One thing is certain, that they will give to the world many new and vital discoveries.[14]

Contemporary Definitions of Plastics

Barnhart's American College Dictionary defines plastics as follows: Plastics is a material capable of being molded or shaped by heat and pressure. Plastics are of any group of synthetic or natural organic materials which may be shaped when soft and then hardened, including many types of resins, resinoids, polymers, cellulose derivatives, casein materials, and proteins.[15]

There are some natural materials such as clay, rubber, and shellac that would fit the above description. However, we are interested primarily in the man-made materials when we now speak of plastics. These man-made plastics are synthesized in chemical laboratories from combinations of oxygen, hydrogen, nitrogen, carbon, and other elements.[16] These basic elements are referred to as the "Big Four" of the chemical plastics industry.[17]

According to Robert S. Swanson in his book Plastics Technology,

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[14]Union Carbide, ABC's of Modern Plastics, (2d Ed., Rev.), (New York: Union Carbide Corporation, Plastics Division, 1958), p. 5.

[15]Clarence Barnhart, (ed.), American College Dictionary, Text Edition, (New York: Harper & Brothers publishers, 1957), p. 928.

[16]The Society of the Plastics Industry, The Story of the Plastics Industry, op. cit., p. 6.

[17]University of North Dakota, op. cit.

> The Official definition of plastics accepted by the Society of Plastics Engineers (SPE) and the Society of Plastics Industry (SPI) is 'a large and varied group of materials which consist of or contain as an essential ingredient a substance of high molecular weight which, while solid in the finished state, at some stage of its manufacture is soft enough to be formed into various shapes--most usually through the application (either singly or together) of heat and pressure'.[18]

All plastics materials are classified in two categories, (1) thermoplastics, and (2) thermosettings.[19] Thermoplastics are those that change only physically when heat and pressure are applied for the purpose of molding or forming. They become soft when heated and hard when cooled. This process can be accomplished endless number of times without altering the chemical structure of the material. Some examples of thermoplastic materials are: nylon, acrylic, polyethelene, fluorocarbons, vinyl, etc. Thermosetting materials however, are those plastic materials that change both physically and chemically when heat and pressure are applied for the purpose of molding and forming. These materials become soft when heated and hard when cooled. Reheating will not soften a thermosetting material. Some examples of thermosetting plastics are: alkyd, amina (melamine and urea), epoxy, cold molded, phenolic, polyester, polystyrene, silicone, etc.[20]

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[18] Robert S. Swanson, Plastics Technology (Illinois: McKnight & McKnight Co., 1965), p. 17.

[19] Ibid.

[20] Society of Plastics, The Story of the Plastics Industry, op. cit., pp. 6-7.

CHAPTER III

THE INDUSTRIAL PROCESSES APPLICABLE TO INDUSTRIAL ARTS EDUCATION

The industrial processes of the plastics industry are categorized into five groups; molding, casting, thermoforming, reinforcing, and foaming.[21] Each of these groups are subdivided into individual processes. Only those processes that are applicable to industrial arts education will be described.

Molding Process

This group is divided into eight individual processes, compression molding, transfer molding, injection molding, extrusion, blow molding, calendering, and laminating.[22] Each of these processes, with the exception of extrusion and calendering, can be interpreted in any industrial arts curriculum at a limited cost.

Compression molding, transfer molding, and cold molding are very similar processes. They each use matched-die molds, and utilize thermosetting materials. Each process will be described to show its particular characteristics.

In compression molding, the molds are heated to between 300° and 400°F. The plastic material (measured amount) in pellet and powder form is preheated and placed in the mold cavity. When the mold is

[21] Swanson, op. cit., pp. 60-61.

[22] Ibid., p. 62.

brought together, the heat and pressure cause the plastic to liquefy and spread throughout the mold. The mold is left closed so that the product can cure. After curing is complete, the product is ejected.[23] Example of a compression mold is shown in figure 1.

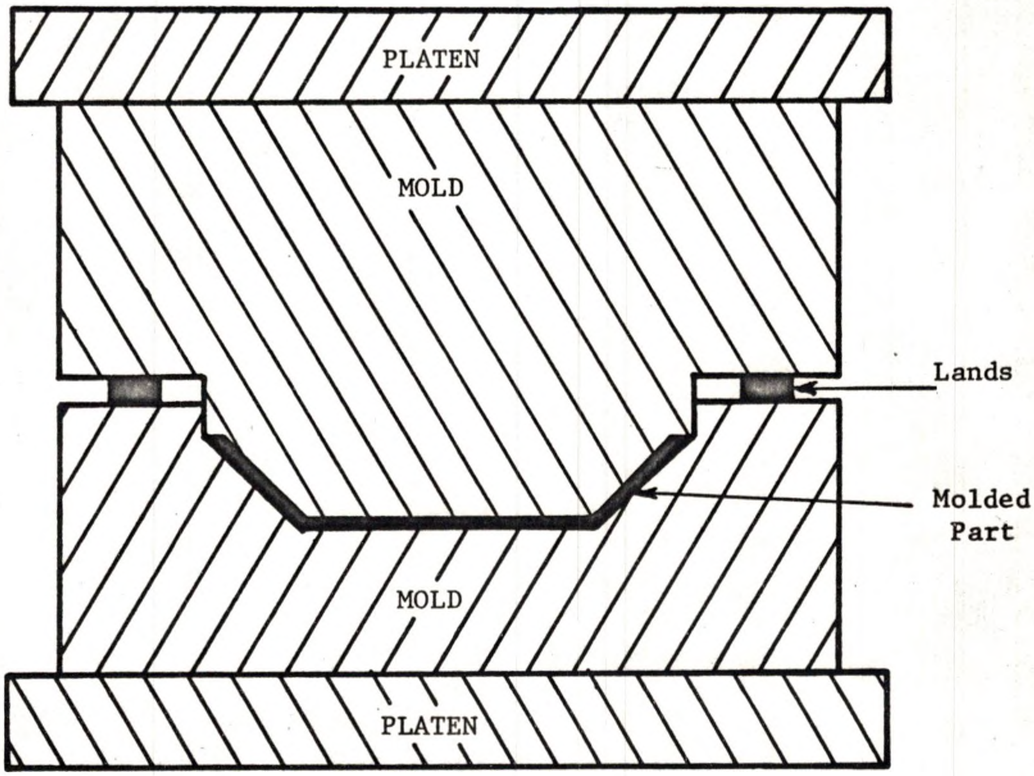

Fig. 1 - Compression Molding

Transfer molding is an adaption of compression molding.[24] In

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[23]The Society of the Plastics Industry Inc., Compression and Transfer Molding, a pamphlet prepared by the committee on plastics education (New York: American Visuals Corp., 1966), pp. 6-7.

[24]Swanson, op. cit., p. 64.

compression molding the plastic material is rather stiff when it is forced throughout the mold cavity. Any product that has a lot of sharp angles and crevices could not be produced by the compression molding processes. In the transfer molding process the mold and transfer chamber are heated. The plastic material is liquefied and placed in the transfer chamber. A transfer plunger forces the plastic through a sprue hole into the mold. The product is allowed to cure and is then ejected.[25] Example of a transfer mold is shown in Figure 2.

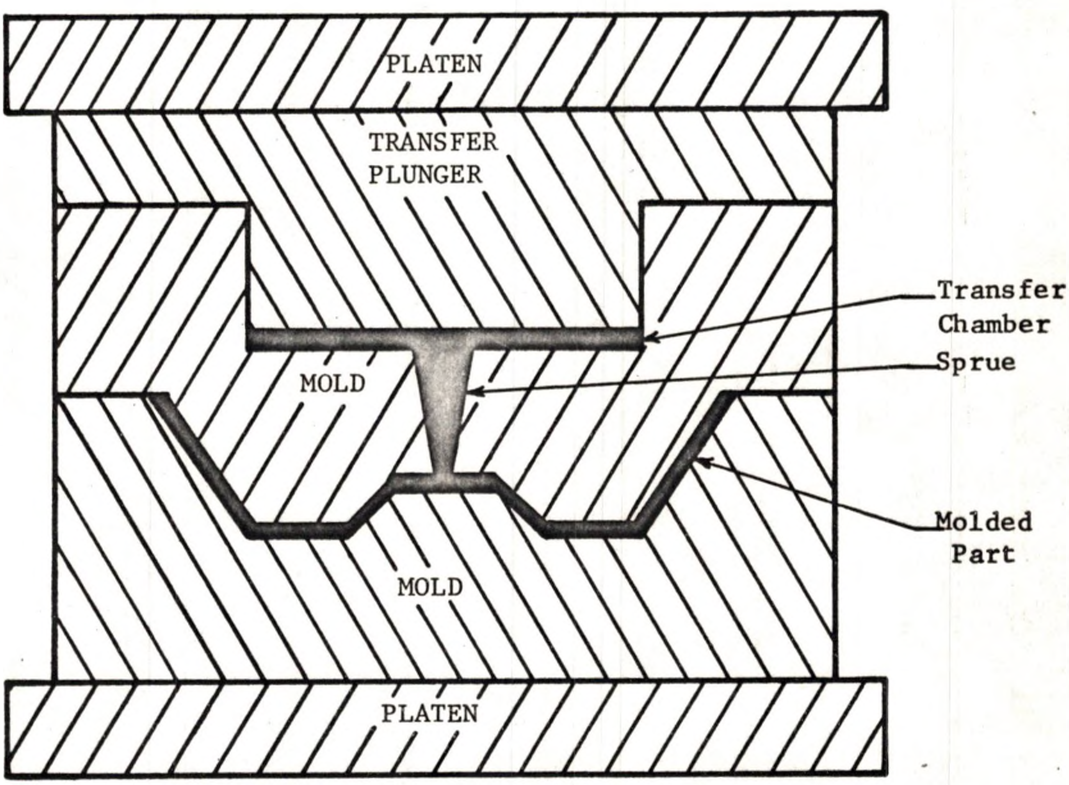

Fig. 2 - Transfer Molding

[25] The Society of the Plastics Industry Inc., Compression and Transfer Molding, op. cit., pp. 8-9.

In cold molding, the plastic material is mixed to a thick consistency and placed into a mold similar to that of the compression mold. The mold is closed and pressed together at 2000 to 4000 psi. The molding is completed without heat. After the product is removed from the mold, it is placed in an oven to bake at 450^{o} for about 72 hours in order to fuse the resin.[26] Example of cold molding is shown in figure 3.

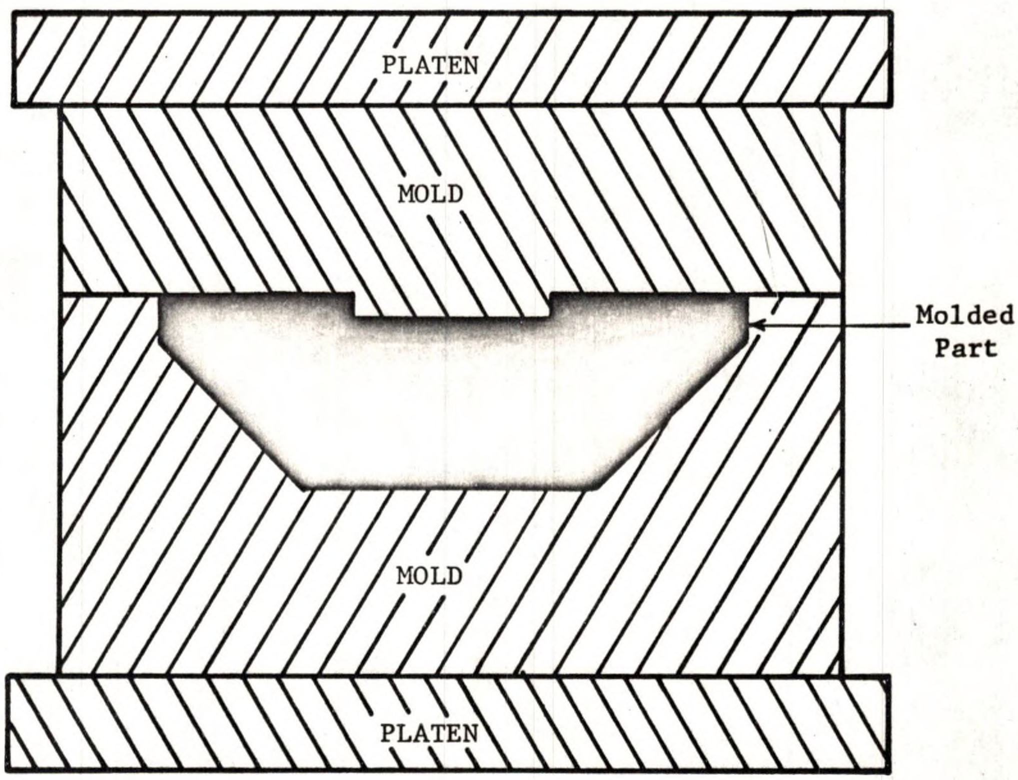

Fig. 3 - Cold Molding

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[26]Swanson, op. cit., p. 74.

Molds for the above processes can be fabricated in the metals laboratory. It has been determined through experimental work, that the model 150 Carver Laminating Press in figure 4 is adequate for interpreting these processes in Industrial Education.

Laminating is a process of bonding two or more layers of any material. The lamination of materials impregnated with plastic resin will be described. Layers of material, such as cloth, paper, asbestos, etc., are impregnated with a thermosetting resin. The excess resin is removed and the remaining resin is left to dry, not cure. Layers of resin impregnated material are assembled to the proper thickness, heat and pressure are applied, causing the resin to flow and harden the laminate into a solid mass.[27] The model 150 Carver Laminating Press in figure 4 is adequate for the purpose of interpreting this process in industrial arts.

Injection molding is somewhat like transfer molding in that the plastic material is injected through a sprue hole into the mold cavity. In this process, only thermoplastic material can be used. The thermoplastic material in powder or pellet form is placed in a hopper. The plastic is forced from the hopper into the heating chamber and spread out against the walls with a torpedo and liquefied at about 300° to 650°F. After the material is in a liquid state, it is forced through a nozzle into a closed cold mold at about 5,000 to 40,000 psi. The molded product is allowed to cool and solidify in the mold and is then removed.[28] An example of the press is shown in figure 5.

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[27] Ibid., p. 72.

[27] Ibid., p. 66.

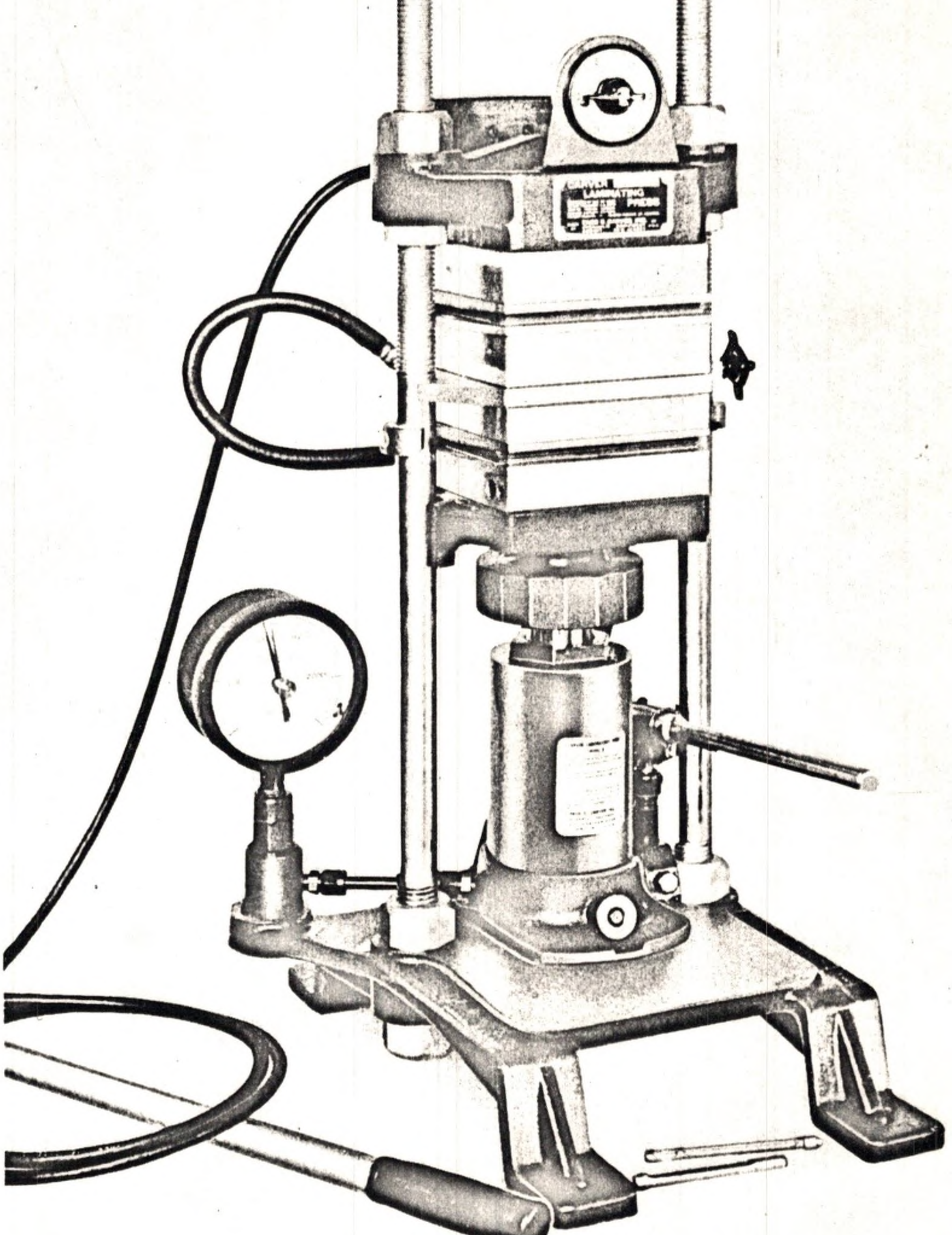

Fig. 4 - Carver Laminating Press Model 150.
Courtesy Fred S. Carver Inc.

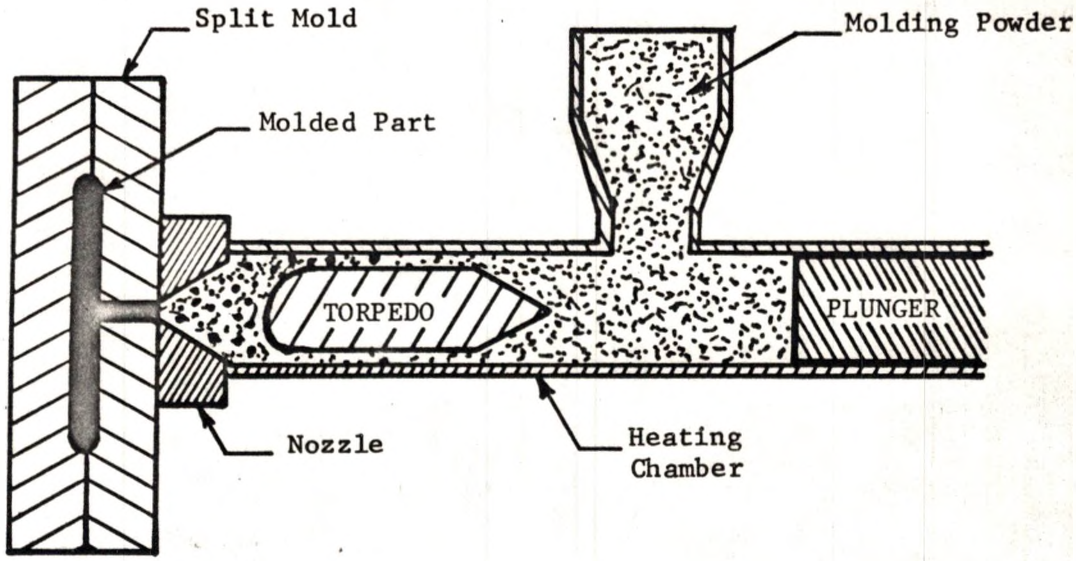

Fig. 5 - Injection Molding

In figure 6 is shown an automatic injection molding machine that is used in industry. This type would be very expensive for industrial arts purposes. For industrial arts education purposes, the injection molding machine in figure 7 would be sufficient to interpret this process. The first "American made" injection molding machine, built in 1931, by HPM Corporation is shown in figure 8.

Casting Process

The casting process utilizes several techniques, that of simple casting in an open mold, rotational, slush, or dipping process.[29]

In simple casting, both thermosetting and thermoplastic materials can be used. The plastic resin is catalyzed and simply poured

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[29] Ibid., p. 77.

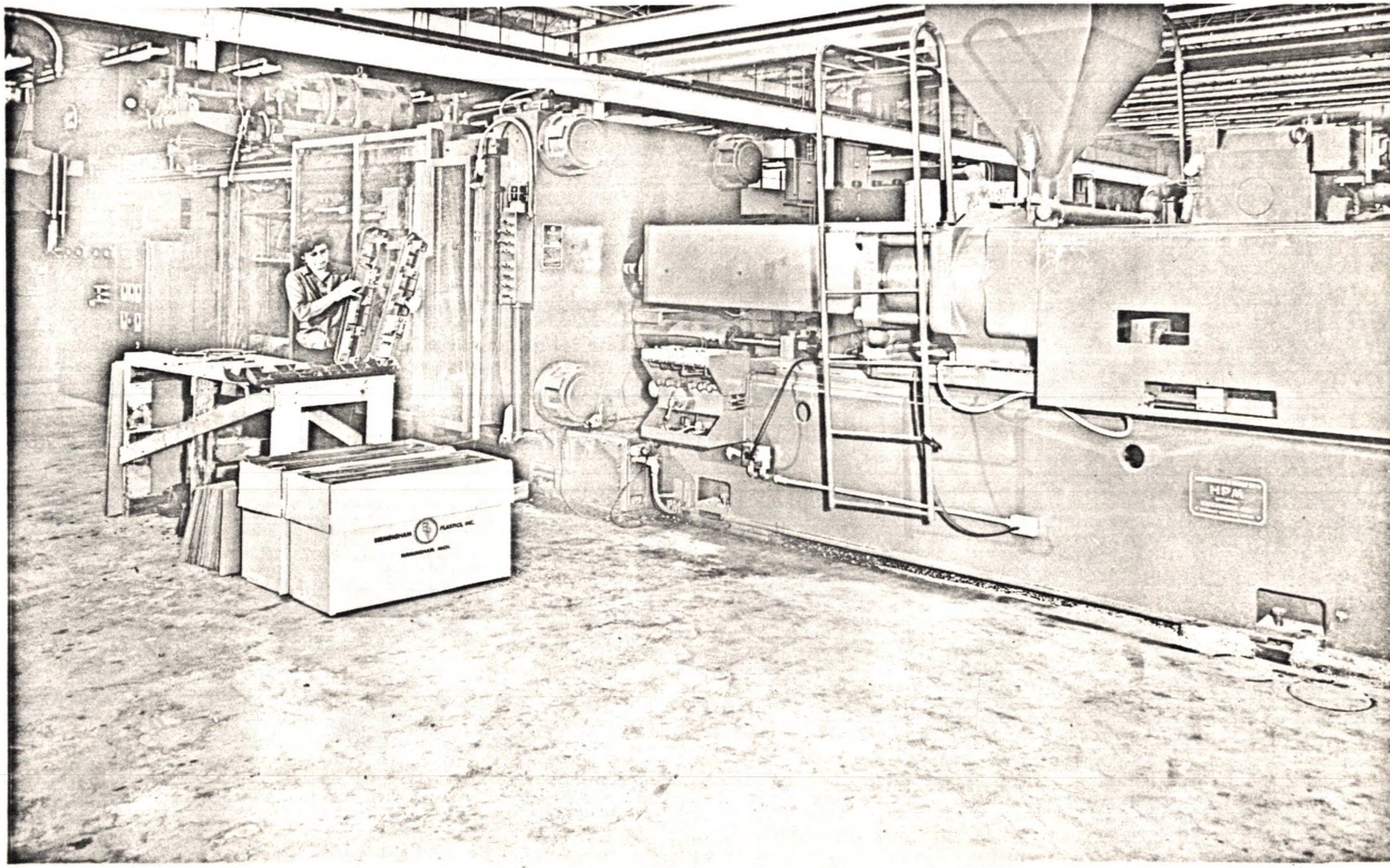

Fig. 6 - Industrial Model of Automatic Plastic Injection Molding Machine. Courtesy HPM Corp.

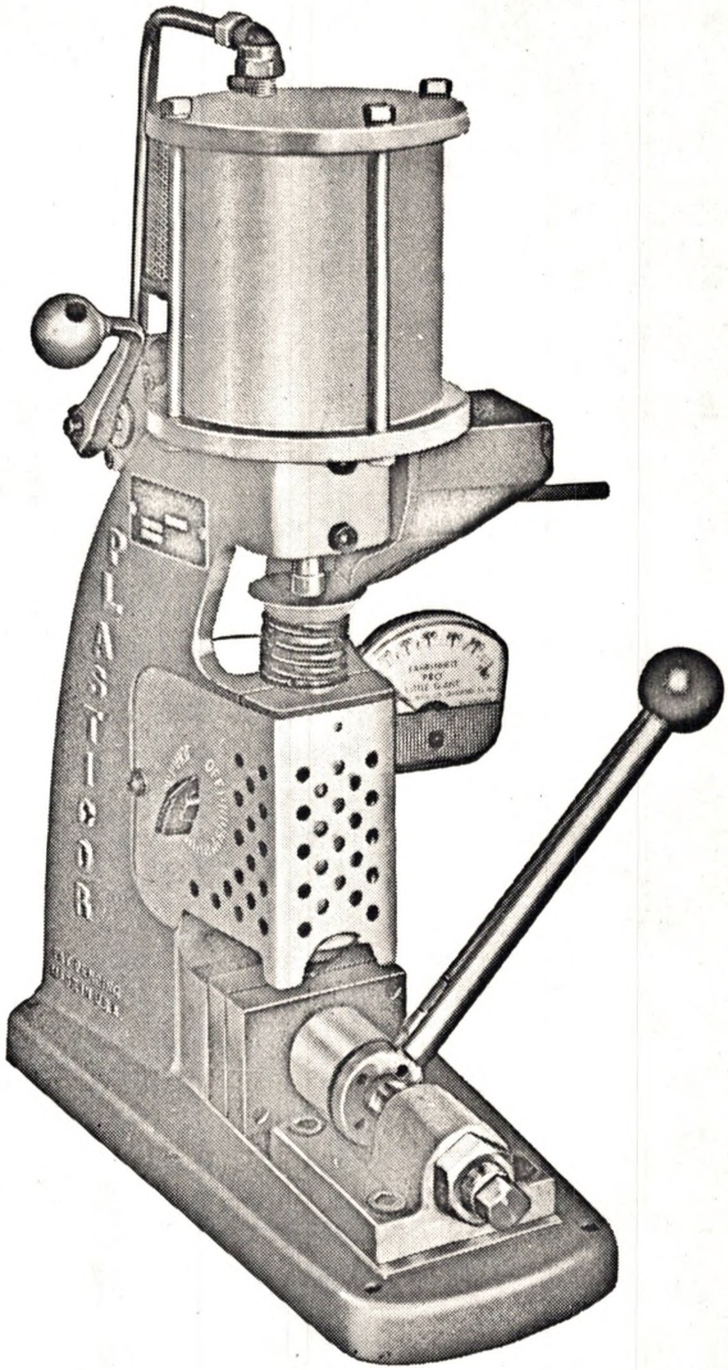

Fig. 7 - Laboratory Type Plastic Injection Molding Machine Model PLA -63. Courtesy Simplomatic Mfg. Co.

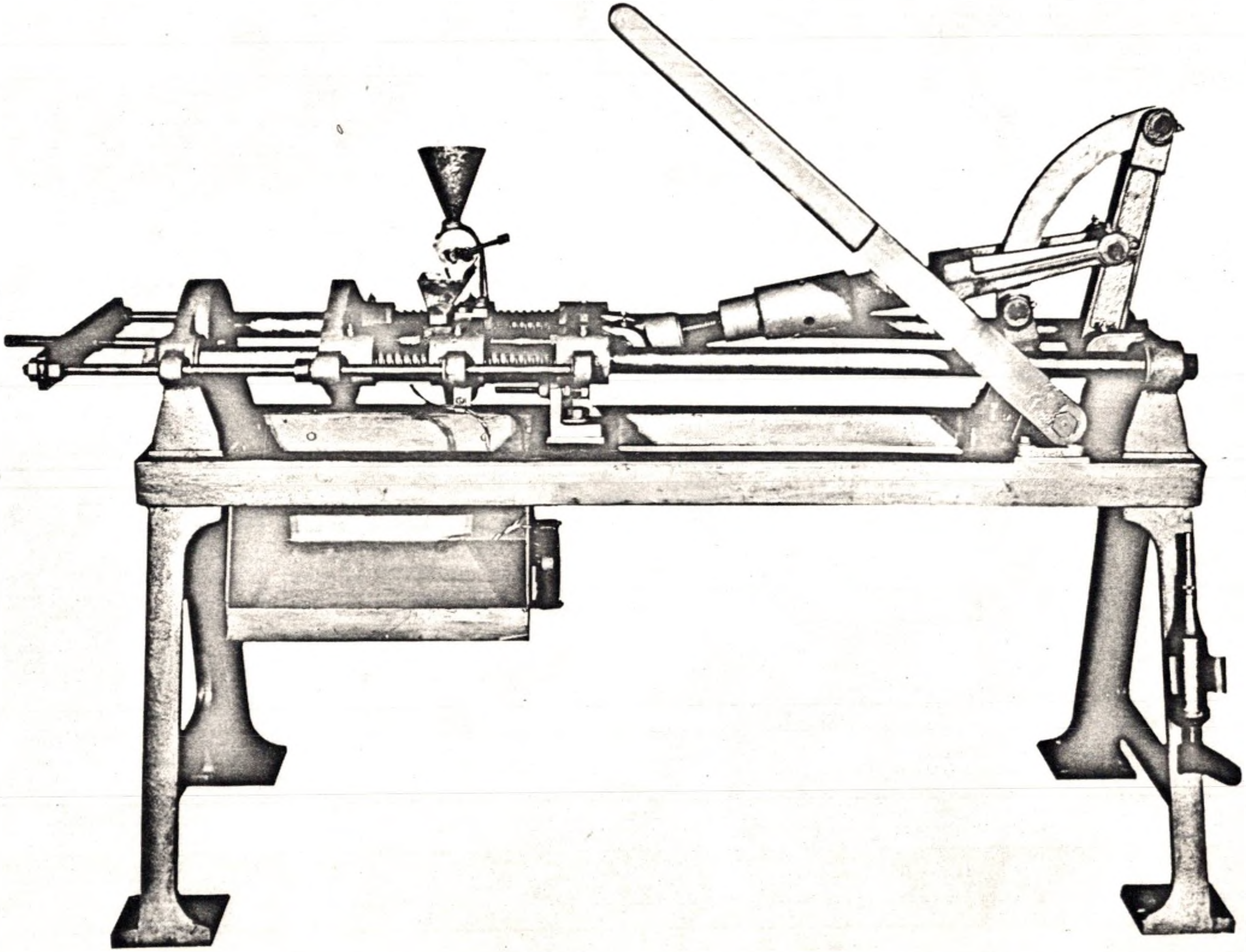

Fig. 8 - First "American Made" Plastic Injection Molding Machine 1931. Courtesy HPM Corporation.

into an open or closed mold. The product is allowed to cure at room temperature or in an oven at low heat. After the plastic is cured, it is removed from the mold. This process is used for solid objects.[30]

The rotational and slush processes are used to produce hollow products. In dip casting, a plug the size of the inside of the article to be produced is heated and dipped into liquid resin. The plug is withdrawn at a given rate with the liquid plastic adhering to the heated plug. The speed of withdrawal controls the thickness of the layer of plastic. The plug and solidified plastic are allowed to cure in an oven at 350° to 400°F. After curing, the plastic is stripped from the plug.[31] This process can be used to coat metal handles of pliers and other tools for protection against electrical shock and heat.

Slush casting is a process used for hollow objects of irregular shapes, for articles that could not be peeled off a plug. In this process, a split mold with a cavity the size of the outside of the article to be cast is used. The mold is heated and filled with liquid resin. The period of time that the liquid plastic is permitted to stay in the mold determines the thickness of the layer of plastic. Excess liquid is poured out of the mold. The solidified plastic and mold are allowed to cure in an oven at 350° to 400°F. After curing, the article is removed from the mold.[32]

Rotational casting is accomplished in a closed split mold. A

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[30]Ibid.,

[31]Ibid., pp. 78-79.

[32]Ibid., p. 79.

measured amount of liquid resin is placed in the mold. The mold is placed in a heated 350° to 400° oven and rotated in two planes. After cure, the article is removed from the mold.[33] This process is used for articles such as hollow plastic balls, plastic globes, etc.

Thermoforming Process

There are three types of thermoforming that are used alone or by combination to stretch a heated sheet of plastic. They are, mechanical, vacuum, and blow forming.[34]

Mechanical forming, sometimes called drape forming, is accomplished simply by heating a piece of sheet plastic and mechanically stretching it over a mold. The product is cooled and then removed from the mold.[35]

In vacuum forming, the heated plastic sheet is brought down in contact with the edges of the mold, and the air is removed from the mold cavity through exhaust holes. When a vacuum is created in the mold cavity, the plastic sheet is forced into the contours because of the atmospheric air pressure differential.[36]

Blow forming is just the opposite of vacuum forming. The mold is brought in contact with a sheet of heated plastic. Air under pressure is injected through a hole in the platen under the plastic sheet and forces the sheet into the mold contours. Exhaust holes are

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[33] Ibid., pp. 79-80.

[34] Ibid., p. 82.

[35] Ibid.

[36] Ibid., pp. 82-83.

provided in the mold so that the entrapped air can escape.[37]

In the thermoforming process, only thermoplastic sheets are used. Thermoset sheets of plastic will not resoften once they are cured. The materials most used in this process are the vinyls, styrenes, and acrylics.[38]

Reinforcing Process

There are several techniques of this process to include; hand lay-up, spray-up, matched molding, premix molding, and vacuum or pressure bag molding.[39]

In the hand lay-up, a male or female mold is used. A releasing agent is applied to the mold so that the resin will not adhere to the mold surfaces. After the mold is prepared, a coat of resin, called gel coat, is applied with a brush, roller, or spray gun. After this gel coat has cured, successive layers of cloth or mat, usually fiber glass, are impregnated with resin and placed over the mold. The surface is rolled to remove air bubbles from under the surface. The mold and resin are allowed to cure after each layer of impregnated cloth or mat. Enough layers are applied to accomplish the desired strength of the end product. After complete cure, the product is removed from the mold.[40]

Spray-up is the same as hand lay-up except that the resin and chopped glass fibers or continuous roving are applied with a spray

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[37] _Ibid._, pp. 84-85.

[38] _Ibid._, p. 85.

[39] _Ibid._, p. 88.

[40] University of North Dakota, _op. cit._

gun. The product is cured and then removed from the mold.[41]

In the matched molding method, a set of molds is used to form the end product. The reinforcing material is preformed to the approximate shape of the finished product. This preform is placed in the mold, the resin is added, and the mold is closed and heated. This causes the resin to flow, impregnate the reinforcing material, and cure. The finished product is removed from the mold after it is completely cured.[42]

A set of matched molds is used in premix molding as in matched molding. In premix molding, the resin and chopped glass fibers are mixed together to form premix or "gunk." A predetermined amount of "gunk" is placed in the mold and the mold is closed. Heat and pressure are applied which causes the "gunk" to flow and cure. After curing, the finished product is removed.[43]

Pressure bag molding is used by industry to manufacture large items at less cost than previously mentioned methods. The resin and reinforcing material are placed in the mold or over a partially inflated rubber bag. The bag is placed in the mold and inflated. The pressure in the bag forces the resin and reinforcement into the contours of the mold. The product is allowed to cure under pressure and is then removed from the mold.[44]

In vacuum bag molding, the resin and reinforcement are laid

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[41]Ibid.

[42]Swanson, op. cit., pp. 90-91.

[43]Ibid., p. 91.

[44]Ibid., pp. 91-92.

up over the mold in a fashion similar to that in hand lay-up or spray-up. The mold and the green reinforced plastic are placed in an air-tight bag and the air is removed from the bag. Air pressure forces the bag against the mold and forms the product. The mold is left in the vacuum until the plastic is cured. The finished product is removed from the bag and mold after curing.[45]

The molds for each of the processes just mentioned can be purchased from jobbers, or they can be manufactured in the industrial arts department. The molds for industrial arts' use can be made from metal, plastic, or wood.

Foaming Processes

The foaming process is divided into two methods, physical foaming and chemical foaming. In the physical foaming, the cell forming agent is a gas. In the chemical forming the expanding agent is a reaction of two chemicals being combined. A further classification of the two principal foaming processes is molding expandable polystyrene and casting polyurethane.[46]

A set of steam vented matched molds is used in the molding of expandable polystyrene. It is necessary to pre-expand the styrene beads to the desired density before the molding process. An example of a radiant head pre-expander is shown in figure 9. This pre-expander can be manufactured in the industrial arts laboratory, or several sizes are available from the Rainville Company, Inc., 224

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[45] *Ibid.*, p. 92.

[46] *Ibid.*, p. 95.

Seventh Street, Garden City, Long Island, New York.[47]

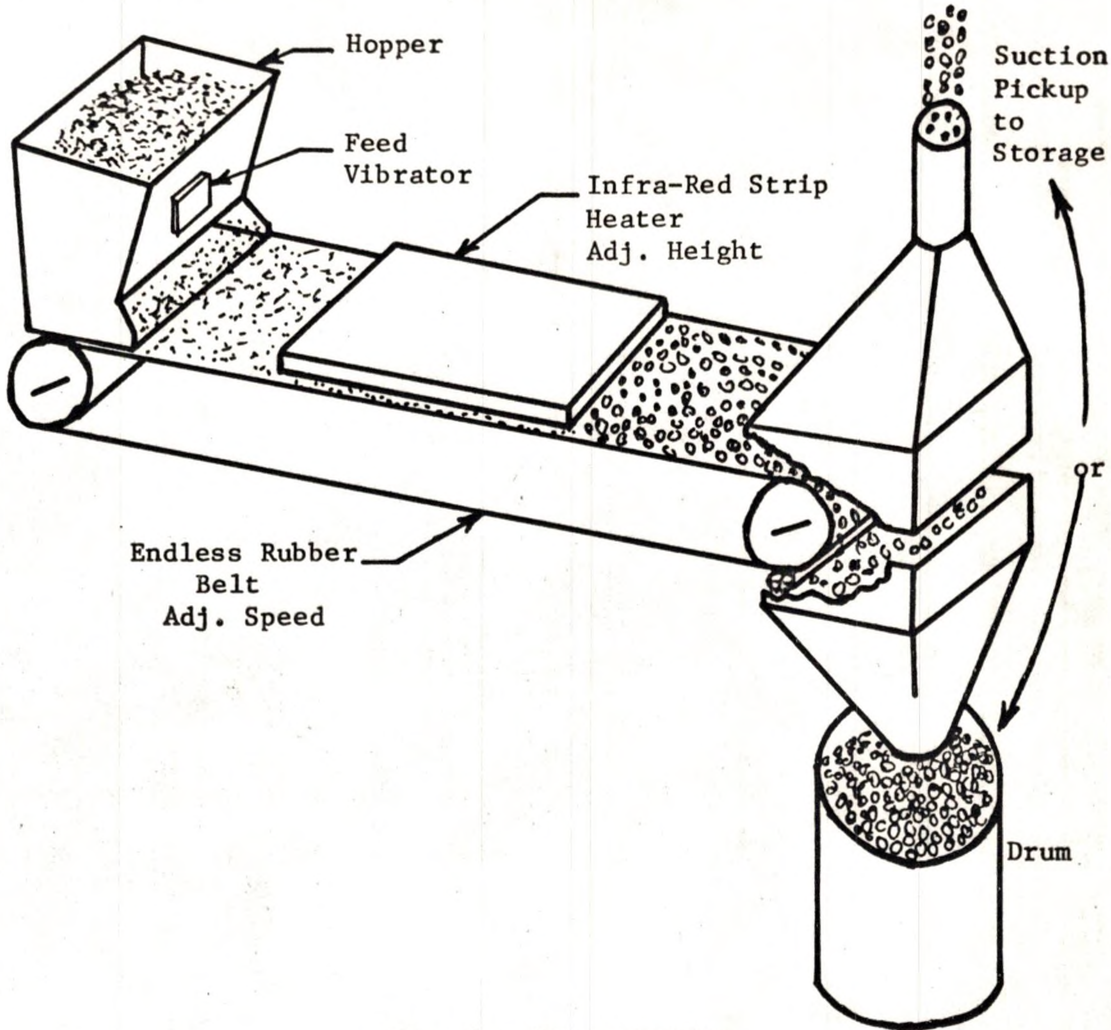

Fig. 9 - Pre-expander

Polystyrene beads can also be pre-expanded in boiling water. Beads are poured into the boiling water. They then rise to the top and expand from the heat. The longer the bead is left in the boiling water, the larger the bead.[48]

Polystyrene beads should not be used immediately after

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[47]Koppers, Technical manual, Dylite expandable polystyrene, Bulletin C-9-273, Chapter 36 (New York: Koppers Company, Inc., November, 1959).

[48]University of North Dakota, op. cit.

pre-expansion. It has been determined through experimental work that the beads should cure for 24 to 48 hours. A much superior product is produced with cured beads.[49]

When beads are cured, the closed mold is loaded. The mold is heated to about 275° by one of many different ways. The mold can be immersed in boiling water, heated in an ordinary oven, or placed in a steam chest. Each method has its own characteristics. Through experimentation, the steam chest method has proven to be the most effective. The exact temperature and amount of time will be determined by method of heating, density of the beads, and size of the mold. After expansion, the mold and product are cooled as to prevent further expansion or distortion.[50]

The steam chest used in this process could be an ordinary auto-clave. They are sometimes available from a hospital that has purchased a newer model or is getting rid of it for other reasons. The molds for the process can be made in the industrial arts laboratory or they can be purchased from Decoys Unlimited, Clinton, Iowa.

In the casting of urethane foam, a set of matched molds is also used. The mold has a sprue hole in the top for filling. The resin and foaming agent are mixed in proper proportions and poured into the mold. The foam is allowed to expand and cure, then the part is ejected from the mold.[51]

An example of its use is in a compartment of a boat to aid in floatation. The resin and foaming agent are mixed and poured

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[49] Ibid.

[50] Ibid.

[51] Swanson, op. cit., pp. 96-97.

or forced into the cavity and allowed to foam and fill the void.

Foam molded products are used as insulation, packaging, toys, christmas ornaments, etc. Whereas, cast foam is used to fill voids for purpose of floatation or insulation.[52]

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[52] *Ibid.*, p. 97.

CHAPTER IV

THE INDUSTRIAL PLASTICS PROGRAM

The Laboratory

An industrial plastics education program can be implemented in a general shop or unit shop program of industrial arts education at any level. In the general shop, industrial plastics should be given equal consideration in terms of emphasis with the other curriculum areas of instruction in industrial arts education. In the unit shop, the area most compatible with plastics would be that of wood technology because of the common usage of tools and equipment.[53]

Most cutting, drilling, sanding, and finishing that needs to be done on plastic materials can be accomplished with wood cutting tools. In some instances, such as cutting formica, metal cutting tools should be used. Formica is much harder than other plastic materials and it will damage wood cutting tools.

Course Outline

A current and up-to-date course outline should include each of the following, an introduction, purpose of the course, objectives of the course, methods of achievement, outline of topics to be considered, and reference materials. The following course outline is

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[53]University of North Dakota, op. cit.

suggested, by the writer, for an industrial plastics education course for all industrial arts education programs.[54]

Introduction

Industrial plastics is the segment of instruction in industrial arts education that represents and assimulates the plastic industry. It is a study of the industry in terms of its industrial processes, products, tools, materials, and problems. In this course, instruction will give emphasis on the development, in each student, a general knowledge, understanding, and insight into the industry. This development will be accomplished through, student reports, small and large group discussion, observation in industry through field trips and/or films, lecture-demonstrations, readings, and activities related to the industry.[55]

Purpose of the Course

The purpose of this course is to develop, in each student, an insight and understanding of the plastics industry. This course is devoted to the industrial processes, products, tools, materials, problems, and technological developments of the industry.[56]

Objectives of the Course

1. To develop in each student an insight and understanding of the history, growth, scope, and place of the plastics industry in our society.

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[54] Ibid.

[55] Ibid.

[56] Ibid.

2. To discover and develop student talent in the plastics industry.

3. To develop problem-solving abilities related to the processes, products, tools, materials, and terms of the plastics industry.

4. To develop in each student, skill in the safe use of tools and machines of the plastic industry.[57]

Method of Achievement

Learning experiences will be provided, which parallel the objectives, by lectures, demonstrations, small and large group discussion, observations on field trips, visual aids, practical and experimental laboratory applications, and student reports.[58]

Unit I. HISTORY OF THE INDUSTRY

A. How the Industry Grew.
B. Growth of an Industry
C. Scope of the Industry
D. Introduction of Plastic Materials
E. Composition of Plastics
F. Plastics: What are they?
    1. Thermoplastic
    2. Thermosetting
G. Manufacturers
    1. Plastic materials manufacturers
    2. The Fabricators and Finishers
    3. The Chemical Industry
H. Industrial processes - General
    1. Molding
    2. Casting
    3. Thermoforming
    4. Reinforcing
    5. Foaming

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[57]ACIAS, Industrial Arts Education (Illinois: McKnight & McKnight Publishing Co., 1963), pp. 4-5.

[58]University of North Dakota, op. cit.

Unit II. MOLDING PROCESSES

A. Compression molding
B. Transfer molding
C. Injection molding
D. Laminating
E. Cold molding
F. Others

Unit III. CASTING PROCESS

A. Simple Casting
B. Plastisol Casting
   1. Dip molding
   2. Slush molding
   3. Rotational molding

Unit IV. THERMOFORMING PROCESS

A. Mechanical Forming
B. Vacuum Forming
C. Blow Forming

Unit V. REINFORCING PROCESS

A. Hand Lay-up
B. Spray-up
C. Matched molding
D. Premix molding
E. Pressure bag & vacuum bag molding

Unit VI. FOAMING

A. Molding expandable polystyrene
B. Casting urethane foam

Unit VII. MACHINING PLASTICS

A. Cast and extruded plastics
B. Laminated plastics
C. Welding
D. Finishing
   1. Sanding
   2. Polishing
   3. Metalizing

Unit VIII. OCCUPATIONAL OPPORTUNITIES IN PLASTICS TECHNOLOGY

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2. "Materials in Design Engineering," Reinhold Publishing Co., 430 Park Ave., New York 22, New York.

3. "Fabrication of Plexiglas," United States Plastics Corp., 1550 Elida Rd., Lima, Ohio, Cost 35¢.

4. "Plastics Engineering Handbook," The Society of The Plastics Industry, Inc. 3rd Edition, 1960, Cost $15.00.

5. "Modern Plastics," Modern Plastics, Inc., 770 Lexington Ave., New York 17, New York.

6. "Plastics World," Cleworth Publishing Co., Inc., 1 River Road, Cos Cob, Conn.

7. "Plastics Technology," Bill Brothers Pub. Corp., 630 Third Ave., New York 17, New York.

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8. ______________________. "Pressure Differential Forming." Prepared by Luvern Eickhoff. Department of Industrial Arts. 1966.

9. ______________________. "A System for Rotational Casting." Prepared by Luvern Eickhoff. Department of Industrial Arts. 1966.

Needed Teaching Equipment

As previously indicated, the industrial plastics curriculum can be implemented in the general shop or in the unit shop in the area of wood technology. The equipment used in the woods laboratory is very compatible to plastics materials. Almost all plastic materials can be worked with wood cutting tools and machines, without damage to the tools and machines.

Additional equipment, for the course described above, beyond what usually is already present in the woods laboratory, will be suggested at this time. Each major industrial process will be treated separately.

Molding Processes - needed equipment.

Injection molding machine - Plasticor model Pla-63 — Cost $295.00

Laminating Press - Carver Model 150 — Cost $495.00

Molds - these can be manufactured in the industrial arts laboratory, or may be purchased from various jobbers of industrial arts supplies and equipment.

Casting Processes - needed equipment.

Oven - Used commercial oven - — About $ 25.00

Molds - These can be manufactured in the industrial arts laboratory, or purchased from various jobbers of industrial arts supplies and equipment.

Thermoforming Processes - needed equipment.

Vacuum forming machine - available from Industrial Arts Supply, Minneapolis, Minnesota.

Molds - these can be manufactured in the industrial arts laboratories.

Reinforcing Processes - needed equipment.

Molds - these can be manufactured in the industrial arts laboratory.

Foaming Processes - needed equipment.

Pre-expander for polystyrene beads - fabricate in industrial arts laboratory or purchase from the Rainville Company, Inc., 224 Seventh Street, Garden City, Long Island, New York.
Cost about $30.00 to $250.00.

Auto-Clave Hospital Sterilizer Steam Chest - purchased from an auction house, hospital, or government surplus. Cost about $50.00 to $100.00.

Molds - manufacture in the industrial arts laboratory or purchase from industrial arts jobber. Duck decoy molds for expandable polystyrene molding can be purchased from Decoys Unlimited, Clinton, Iowa and Industrial Arts Supply, Minneapolis, Minnesota.

The minimum cost of implementing an industrial plastics curriculum in any industrial arts education program that has a wood technology laboratory would be from $750.00 to $1,500.00 for equipment.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This study was undertaken to determine the historical development and scope of the plastics industry. Also, it was to determine how the plastics industry could be interpreted in industrial arts education through the assimulation of industrial processes, products, tools, materials, and problems of the industry.

A study of literature was undertaken to ascertain those industrial processes most likely to be assimulated in the industrial arts laboratory. A course of study has been developed following the objectives set forth by the U. S. Office of Education. Industrial processes of the industry have also been identified.

Conclusions

It is hereby concluded by this study that the plastics industry has had a major significance on society. Therefore, it is necessary that all youth be acquainted with it in the industrial arts education.

Only those industrial processes that were described in Chapter III are applicable to industrial arts education programs. Other industrial processes not described are prohibative because their cost is not within the budgets of education.

This study has also concluded that the implementation of an industrial plastics program would cost from $750.00 to $1,500.00 for any school that already has a wood technology laboratory.

Recommendations

It is recommended by the writer that all industrial arts education programs implement a program of industrial plastics. This would keep in step with the primary objective of industrial arts, being the interpretation of the major industries.

It is also recommended that a course of study along the lines of the example appearing in Chapter IV be followed to some extent in an industrial plastics course. The course should be taught in the wood technology laboratory because of the compatability of the tools and machines to wood and plastic materials.

APPENDIX I

THE UNIVERSITY OF NORTH DAKOTA

Grand Forks 58201

Department of Industrial Arts

Dear Sirs:

I am in the process of developing a course of study in Industrial Plastics Technology. In order to do this, I am in need of information concerning processes, products, tools, materials, and problems related to the Plastics Industry.

I am a graduate student at the University of North Dakota working toward a Master's Degree in Industrial Arts Education. The course of study is a partial requirement for the degree.

May I ask that you send me educational information on the various fabricating processes and materials used in those processes. Also, any information on films and other teaching aids related to the processes would be much appreciated.

Thank you for your attention concerning this request.

Sincerely yours,

James E. Preston, Grad. Ass't.
Industrial Arts Department
University of North Dakota
Grand Forks, North Dakota 58201

Approved by L. R. Eickhoff Ass't. Prof.________________________

Allied Chemical Corporation
Plastics Division
P. O. Box 365
Morristown, New Jersey
Attn.: Public Relations Department

Bee Chemical Company
2700 East 170th Street
Lansing, Illinois 60438
Attn.: Public Relations Department

Celanese Plastics Company
744 Broad Street
Newark, New Jersey
Attn.: Public Relations Department

Dow Chemical Company
Box 628
Midland, Michigan 48640
Attn: Public Relations Department

E. I. DuPont Chemical Company
Willmington, Delaware
Attn.: Public Relations Department

Eastman Chemical Products Inc.
Chemicals Division
260 Madison Avenue
New York, New York 10016
Attn: Public Relations Department

Ferro Corporation
4150 East 56th Street
Cleveland, Ohio 44105
Attn: Public Relations Department

Monsanto Chemical Company
800 N. Linbergh Blvd.
St. Louis, Missouri 63166
Attn: Public Relations Department

Owens-Corning Fiberglas Corporation
Reinforced Plastics Division
717 Fifth Avenue
New York, New York 10022
Attn: Public Relations Department

Phillips Petroleum Company
Chemical Department Plastics Div.
Bartlesville, Oklahoma 74004
Attn: Public Relations Department

The Society of the Plastics
Industry, Inc.
Western Section
611 South Catalina Street
Los Angeles, California 90005

Society of Plastics, Engineers,
Inc.
65 Prospect Avenue
Stamford, Connecticut

Union Carbide Corporation
Plastics Division
270 Park Avenue
New York, New York 10017
Attn: Public Relations Department

U. S. Industrial Chemicals
Company
99 Park Avenue
New York, New York 10016
Attn: Public Relations Department

APPENDIX II

THE UNIVERSITY OF NORTH DAKOTA

Grand Forks 58201

Department of Industrial Arts

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I am a graduate student at the University of North Dakota working toward a Master's Degree in Industrial Arts Education. The course of study is a partial requirement for the degree.

May I ask that you send me complete information on equipment that you have available for educational use. Also, any information on films and other teaching aids related to your equipment would be much appreciated.

Thank you for your attention concerning this request.

Sincerely yours,

James E. Preston, Grad. Ass't.
Industrial Arts Department
University of North Dakota
Grand Forks, North Dakota 58201

Approved by L. R. Eickhoff Ass't Prof.________________________

Adamson United Company
730 Carroll Street
Akron, Ohio 44304
Calendering Equipment

Admiral Equipment Corporation
661 West Market Street
Akron, Ohio 44303
Attn: Public Relations Department
Foam Dispensing Equipment

Auto-Vac Company
109 Meadow Street
Fairfield, Connecticut
Attn: Public Relations Department
Thermoforming Equipment

Battenfeld Corporation of America
7301 North Monticello Avenue
Skokie, Illinois 60613
Attn: Public Relations Department
Injection Molding Equipment

Ball & Jewell Company, Inc.
Division of Beloit Eastern Corp.
22 Franklin Street
Brooklyn, New York 11222
Attn: Public Relations Department
Conveyors and Dryers

Beloit Eastern Corporation
Washington & Green Streets
Downington, Pennsylvania 19335
Attn: Public Relations Department
Blow Molding Equipment

Binks Manufacturing Company
3114-44 West Carroll Avenue
Chicago, Illinois 60612
Attn: Public Relations Department
Foam Dispensing Equipment

The Black Clawson Company
Plastics Department
Extrusion Equipment
Hamilton, Ohio 45011
Attn: Public Relations Department

Brown Machine Company
Beavertown, Michigan 48612
Attn: Public Relations Department
Thermoforming Equipment

Fred S. Carver Hydraulic Equipment
5 Chatham Road
Summit, New Jersey 07901
Compression & Laminating Processes

Comet Industries, Inc.
1320 N. York Road
Bensenville, Illinois 60106
Attn: Public Relations Department
Thermoforming Equipment

Dake Corporation
641 Robbins Road
Grand Haven, Michigan 49417
Compression & Laminating Processes

Barnett J. Danson & Associates Limited
33 Railside Road
Don Mills, Ontario, Canada
Attn: Public Relations Department
Extrusion Equipment

Davis-Standard
Division of Crompton & Knowles Corporation
P.O. Box 202
Mystic, Connecticut 06355
Attn: Public Relations Department
Extrusion Equipment

Farrel Corporation
Plastics Molding Machinery Division
565 Blossom Road
Rochester, New York 14610
Attn: Public Relations Department
Blow Molding Equipment

Gatto Machinery Development Corporation
134 Rome Street
Farmingdale, L. I., New York
Attn: Public Relations Department
Extrusion Equipment

Hinchman Manufacturing Company, Inc.
259 East First Avenue
Roselle, New Jersey 07203
Attn: Public Relations Department
Injection Molding Equipment

HPM Division
Koehring Company
Mount Gilead, Ohio 43338
Compression & Lamination
Presses

Husky of America, Inc.
200 Bentworth Avenue
Toronto 19, Ontario, Canada
Attn: Public Relations Department
Injection Molding Equipment

Improved Machinery Inc.
Nashua, New Hampshire 03060
Attn: Public Relations Department
Blow Molding Equipment

C. A. Litzler Co., Inc.
234-9 Brookpark Road
Cleveland, Ohio
Compression & Laminating
Presses

Nassau Manufacturing Company, Inc.
923 Old Nepperhan Avenue
Yonkers, New York 10703
Attn: Public Relations Department

The New Britain Machine Company
Plastics Machine Division
New Britain, Connecticut 06050
Attn: Public Relations Department
Injection Molding Equipment

Newbury Industries, Inc.
Newbury, Ohio 44065
Attn: Public Relations Department
Injection Molding Equipment

Pasadena Hydraulics, Inc.
1433 Lidcombe Avenue
El Monte, California 91731
Compression & Laminating
Presses

Polymer Machinery Corporation
Plastic Processing Equipment
27 Woodlawn Road
Berlin, Connecticut 06037
Attn: Public Relations Department

Simplomatic Manufacturing Company
4416 West Chicago Avenue
Chicago, Illinois 60551
Attn: Public Relations Department
Injection Molding Equipment

Sterling Extruder Corporation
1537 West Elizabeth Avenue
Linden, New Jersey
Attn: Public Relations Department
Extrusion Equipment

Strong Plastics, Inc.
977 West Hyde Park Boulevard
Inglewood, California 90302
Blow Molding Equipment

Trueblood, Inc.
516 North Irwin Street
Dayton, Ohio 45403
Attn: Public Relations Department
Injection Molding Equipment

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